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PLAN FOR DEVELOPMENT OF THE LAND AND WATER RESOURCES OF THE SOU--ETC(U)
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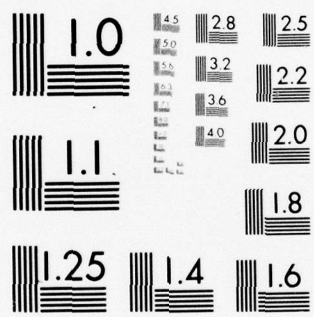

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Plan for Development of the Land and Water Resources of the Southeast River Basins

APPENDIX **10**

HYDROLOGY

APPENDIX **11**

ENGINEERING AND COST

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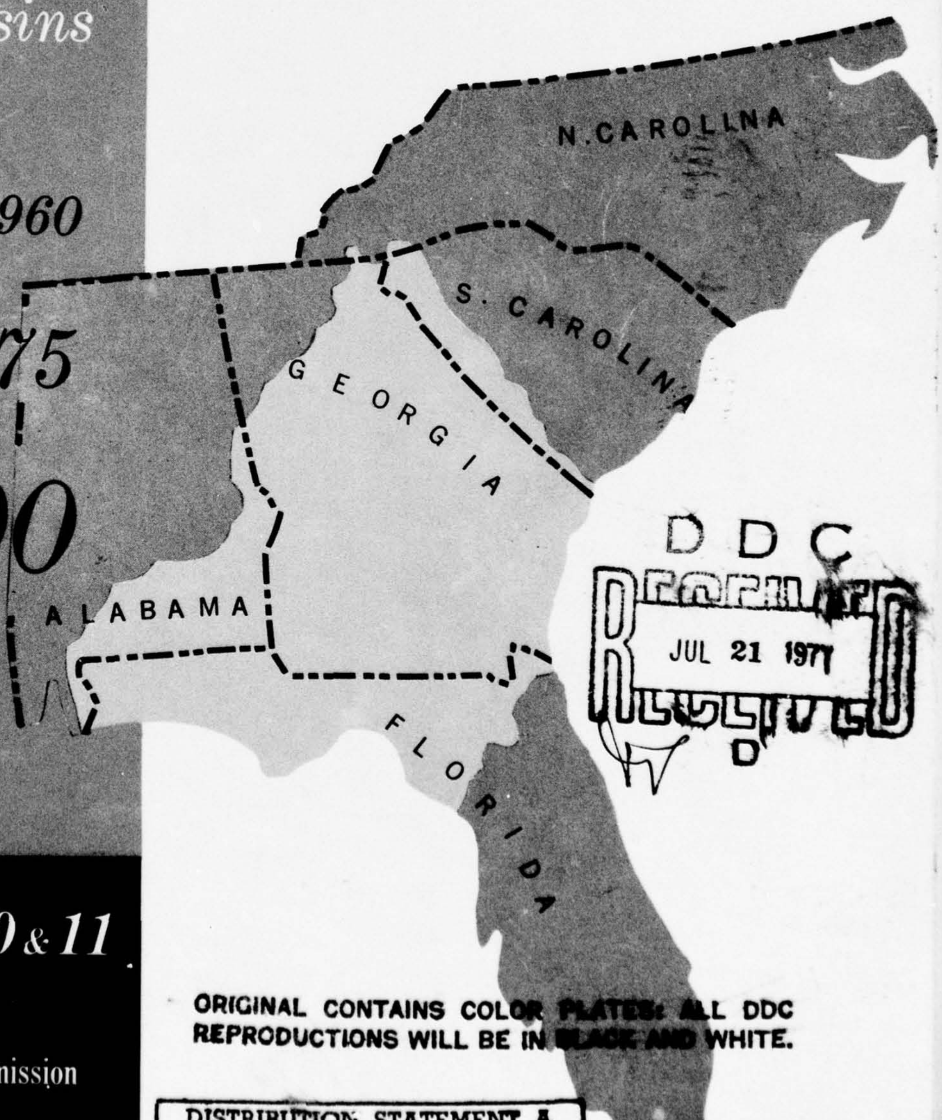

APPENDIXES **10 & 11**

To report of . . .

United States Study Commission

Southeast River Basins

1963

(6)

PLAN FOR DEVELOPMENT OF THE LAND AND WATER RESOURCES OF THE SOUTHEAST RIVER BASINS.

Appendix 10.

HYDROLOGY.

Appendix 11

Engineering and Cost.

(9) Final rept.

APPENDIX 10

TO REPORT OF

UNITED STATES STUDY COMMISSION

SOUTHEAST RIVER BASINS

(11) 1963 (12) 145p.

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FOREWORD

This Appendix supplements the Report of the United States Study Commission, Southeast River Basins, and the other appendixes thereto, by presenting general information on the hydrology of the study area and the results of hydrologic studies.

This Appendix is presented in eight parts. Part One relates the hydrologic studies and data to the overall plan. Part Two deals with the climate of the area; Part Three with water resources and problems connected with their use; and Part Four with trends and technological developments involving use of water which may be expected by the year 2000. Part Five indicates the criteria and methods used in planning for purposes involving water resources, and Part Six lists the basic data reports prepared by cooperating agencies. Part Seven sets forth some of the principal needs for additional data and research activities in the field of hydrology, and Part Eight lists and refers to pertinent publications. The matter contained in each part is pertinent to the comprehensive plan. The reader is urged to consider the Report in the aggregate rather than to consider selected material out of context.

The Report of the United States Study Commission summarizing the plan for the Southeast River Basins is made in response to the provisions of Public Law 85-850 (72 Stat. 1090) dated August 28, 1958, which established the United States Study Commission, Southeast River Basins. Public Law 85-850 is reproduced in Appendix 13.

The authorizing Act provides for an integrated and cooperative investigation to formulate a comprehensive and coordinated plan for:

(1) Flood control and prevention;

(2) domestic and municipal water supplies;

(3) the improvement and safeguarding of navigation;

(4) the reclamation and irrigation of land, including drainage;

(5) possibilities of hydroelectric power and industrial development and utilization;

(6) soil conservation and utilization;

(7) forest conservation and utilization;

(8) preservation, protection, and enhancement of fish and wildlife resources;

(9) the development of recreation;

(10) salinity and sediment control;

(11) pollution abatement and the protection of public health; and

(12) other beneficial and useful purposes not specifically enumerated in the Act.

The comprehensive plan for the Southeast River Basins is formulated to meet the needs of the area for land and water resources development to the year 2000. Projects and programs existing and under construction in 1960 are included in the plan, but only 1960-2000 developments are analyzed.

The plan for the development of the resources of the Southeast River Basins is the result of cooperative work of Federal, State, and local and private agencies having interest in the area and knowledge of its needs and requirements. Public hearings were held early in the planning process to obtain firsthand knowledge of conditions and problems in the study area and to secure suggestions for their solution. Throughout the study, liaison was maintained with interested groups and agencies by means of conferences and committee and advisory group meetings. When a tentative plan was developed, public presentations were made by the Commission to inform interested persons and organizations and to request comments. These comments were considered in preparing the final plan and Report.

Although many individuals, groups, and agencies have participated in the studies, the Commission takes full responsibility for the plan and for the projections, assumptions, and analyses on which it is based.

The Commission plan for the Southeast River Basins is supported by data contained in 13 appendixes. Data on the plan for development of the resources in the eight geographic areas studied in the Southeast River Basins are contained in Appendixes 1 through 8. Technical data and information applicable to both the entire study area and the several geographic

areas are contained in Appendixes 9 through 13. The appendixes to the Commission Report are as follows:

Appendix	Title
1	Savannah Basin
2	Ogeechee Basin
3	Altamaha Basin
4	Satilla-St. Marys Basins
5	Suwannee Basin
6	Ochlockonee Basin
7	Apalachicola-Chattahoochee-Flint Basins
8	Choctawhatchee-Perdido Basins
9	Economics
10	HYDROLOGY
11	Engineering and Cost
12	Planning
13	History and Organization of the Commission

U. S. STUDY COMMISSION
SOUTHEAST RIVER BASINS

APPENDIX 10
HYDROLOGY

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CONTENTS—Continued

CONTENTS—Continued

CONTENTS—Continued

PART EIGHT – BIBLIOGRAPHY

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CONTENTS—Continued

TABLES

THE SOUTHEAST RIVER BASINS

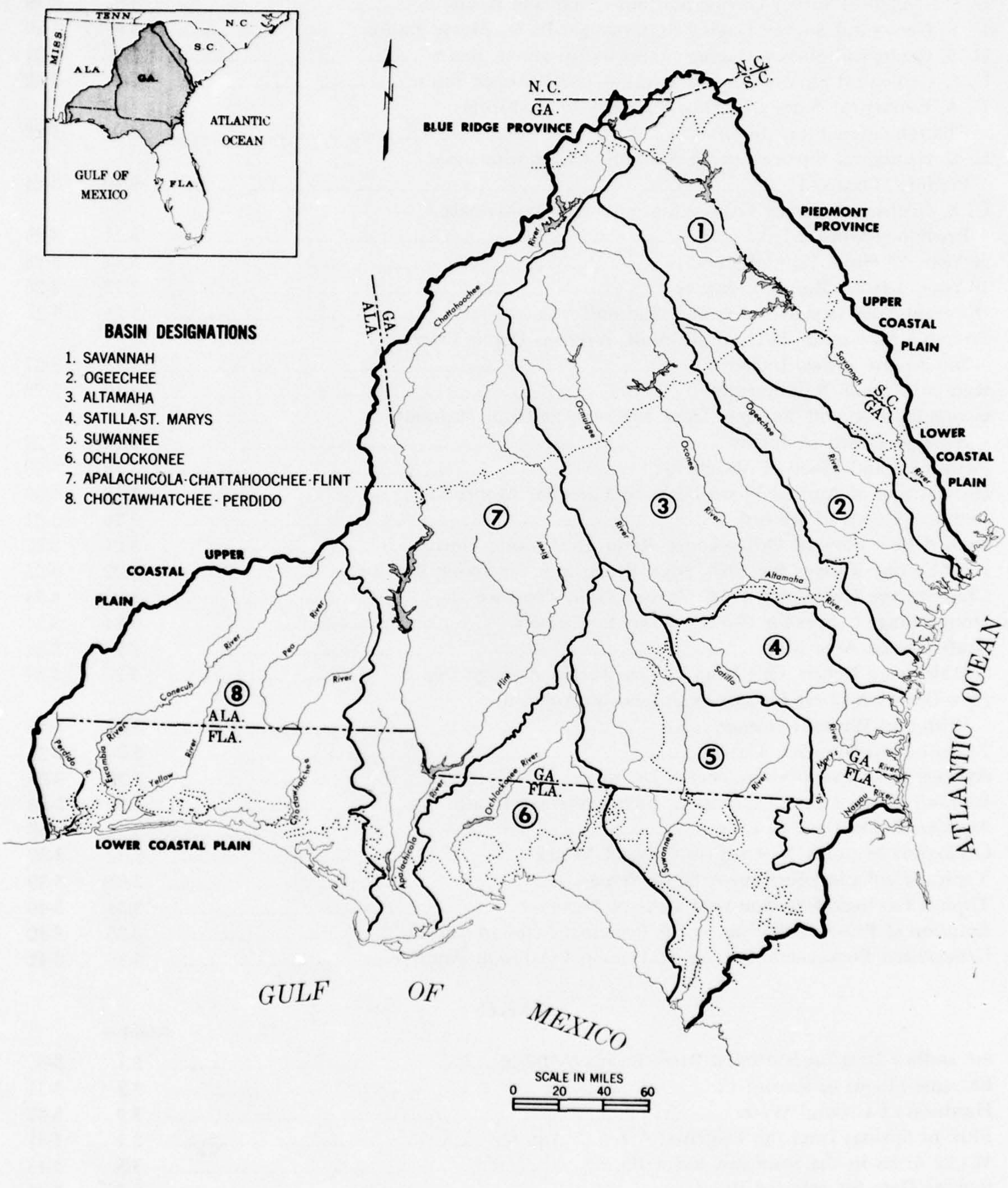


Figure 1.1

PART ONE - INTRODUCTION

The Hydrology Appendix describes, in more detail than is possible in the Report and basin appendixes, the climatic and hydrologic environment of the Southeast River Basins. The Appendix also indicates the nature and amount of basic data available and refers to published sources of such data. The Appendix supports the Report and basin appendixes by explaining pertinent relationships and stating the manner in which data are presented.

The discussion of trends and technological developments is an attempt to look ahead to see if natural trends or cycles or technological developments are likely to make substantial changes in the water regime or in the need for natural water.

In any activity the effort is naturally divided between the purpose-oriented drive to get the job done and the process-oriented effort to meet certain standards of quality and consistency. The Section on Methods and Criteria discusses the decision-making process where the planning methods relate to the discipline of hydrology. In the evolution from agency-oriented limited-purpose planning to the more integrated U. S. Study Commission planning, efforts have been made to understand the reasons for different procedures by different agencies and to help resolve these differences so that planning can be cohesive and so that different segments of the plan can be compatible. Great reliance was placed on the design and other manuals of the cooperating agencies, but planning is still in large measure an art instead of a well-defined and carefully worked-out discipline.

Much of the work in hydrology was done by cooperating agencies. In fact, most of this work had been done earlier and merely needed to be brought together in convenient form to provide the staff and cooperators the background of water availability and rainfall-runoff and other relationships necessary for planning.

Planning requires sampling and examination of relationships among climatic and hydrologic elements which often have largely been observed separately. There is a need for training and experience which will produce a broader understanding of planning techniques and their interrelationships which in the past have only partly been coordinated. As competition for resources and resource programs grows, the balance between data-gathering and data-use will require some sort of efficiency and economic tests.

This Appendix includes a very brief bibliography. Its purpose is to give examples and to show the scope of reading which is basic to an understanding of the climate and hydrology of the Southeast River Basins.

At the end of Part Two, Figures 2.15 through 2.23 show the kind and location of hydrologic observation stations in each of the eight river basins of the study area.

PART TWO – CLIMATE

SECTION I – RAINFALL

Average Rainfall

The average annual rainfall of the Southeast River Basins is about 50 inches. The United States average is about 30 inches. Figure 2.1 shows the average annual rainfall over the study area for the period 1931-55 as given in the Weather Bureau publication, "Climates of the States." The heaviest rainfall occurs in the mountains. Warm moist air masses rise and are cooled as they ascend the slopes of the southern Appalachian Mountains. Moisture condensed from this action falls as rain and makes this the rainiest region in the Eastern United States. Even at the highest elevations, nearly all of the precipitation is rain because the temperatures are mild. Consequently, snow can be neglected as a factor in planning the management of water resources. The smooth isolines of Figure 2.1 do not show the effects of local topography on the distribution of rainfall. While the generalized lines of average annual rainfall do not exceed 68 inches, there are places in the mountains that receive 80 inches of rainfall in an average year. These places are small and scattered and no attempt has been made to identify them.

The extreme southwest portion of the study area receives average annual rainfall of more than 60 inches. This rainfall results from the proximity of this area to a moisture source, the Gulf of Mexico, and from its high humidity, particularly in summer. Along the Atlantic coast is a zone which is subject to a lesser marine influence and which has annual rainfall of about 52 inches. The portion of the study area with the least rainfall is in east-central Georgia and the adjoining portion of South Carolina. In this area, which is relatively far from the mountains and the coast, the annual rainfall averages less than 44 inches. Furthermore, instead of augmenting the rainfall, the mountains tend to shelter this area from late winter and early spring storms from the west and northwest.

Seasonal Distribution of Rainfall

Figure 2.2 shows, by the stepped lines of each diagram, the average seasonal distribution of monthly rainfall for selected representative stations in the study area. The temperature and runoff portions of the diagrams are discussed in Section III of this Part and in Section I of Part Three. In general, the rainfall is fairly well distributed throughout an average year, with most of the rain occurring during the growing season. The early spring peak, which is prominent in the northern part of the study area, is a product of frontal storms which sweep across the continent. The path of these storms migrates seasonally. These storms cross the northern portion of the study area several times a year, particularly in late winter and early spring when they reach their lowest latitudes.

The summer peak, which is more prominent in the southern portion of the study area, is a product of thunderstorms which produce a large portion of the summer rainfall. A very slight autumn peak may be discerned at Savannah and Waycross near the Atlantic coast. This peak may be ascribed to hurricanes and lesser tropical storms. At other southern stations the summer peak extends into the autumn hurricane season. The climatic effect of hurricane rainfall is relatively insignificant because hurricanes occur infrequently at any location, and their aggregate rainfall is small compared with the scattered, though more frequent, thunderstorm rainfall.

The number of days of rain per year in the study area ranges from 130 in the mountains to a little more than 100 along the Gulf coast. This number ranges throughout the United States from more than 150 in parts of New England, the Lake States, and the Pacific Northwest to less than 50 in the arid Southwest. The incidence of rainy days varies somewhat throughout a typical year, averaging about 10 per month. The number, at most places, rises from about 6 per month in autumn to 10 in early spring, dips to 8 or 9 in late spring, and reaches a peak of 12 to 14 in summertime.

Year-to-Year Variability of Rainfall

The variation in total annual rainfall from

AVERAGE ANNUAL RAINFALL IN INCHES

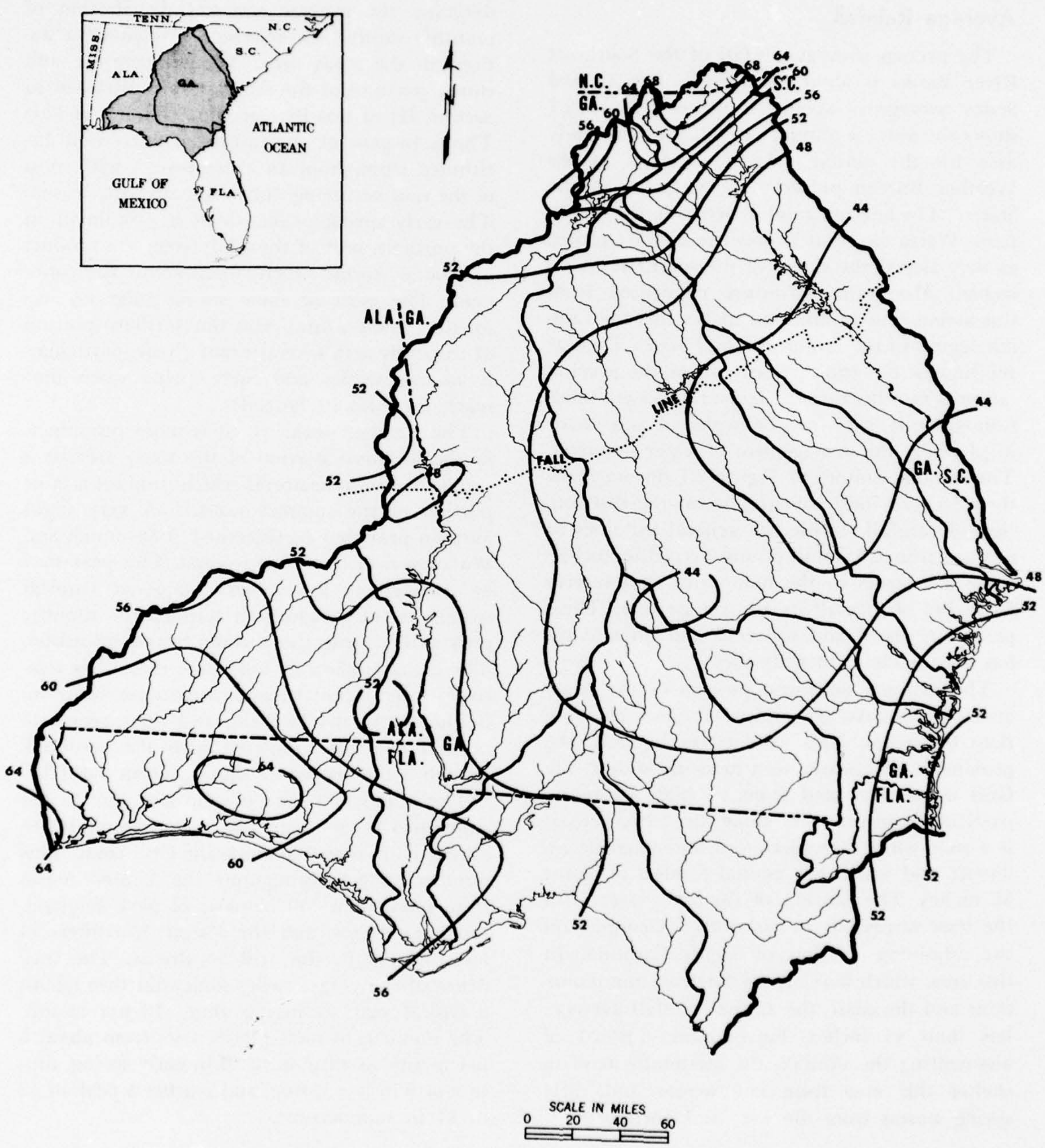


Figure 2.1

TEMPERATURE, RAINFALL AND RUNOFF

AVERAGE SEASONAL DISTRIBUTION BY MONTHS FOR SELECTED LOCALITIES

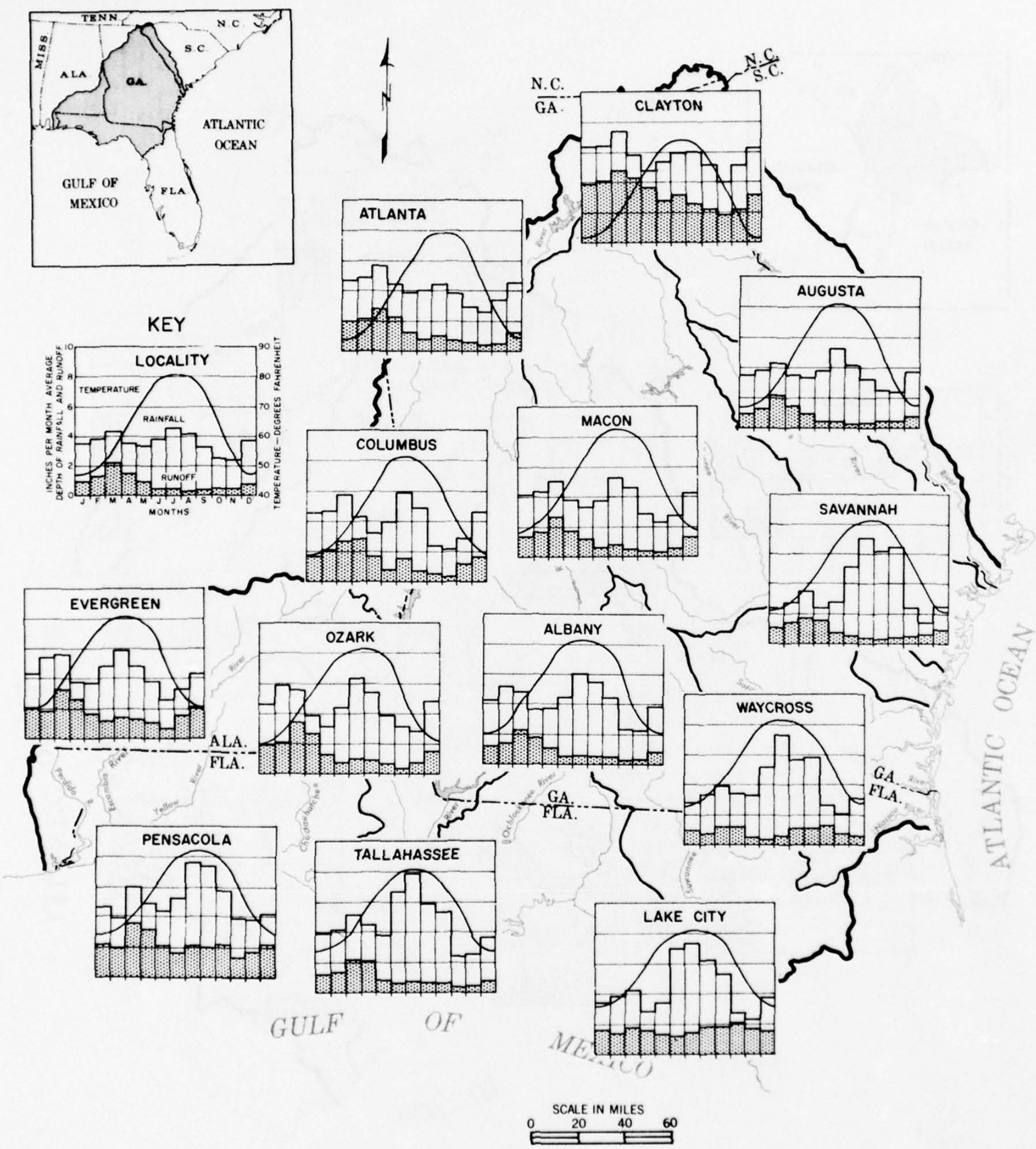


Figure 2.2

RAINFALL AND RUNOFF

YEARLY SEQUENCE FOR SELECTED LOCALITIES

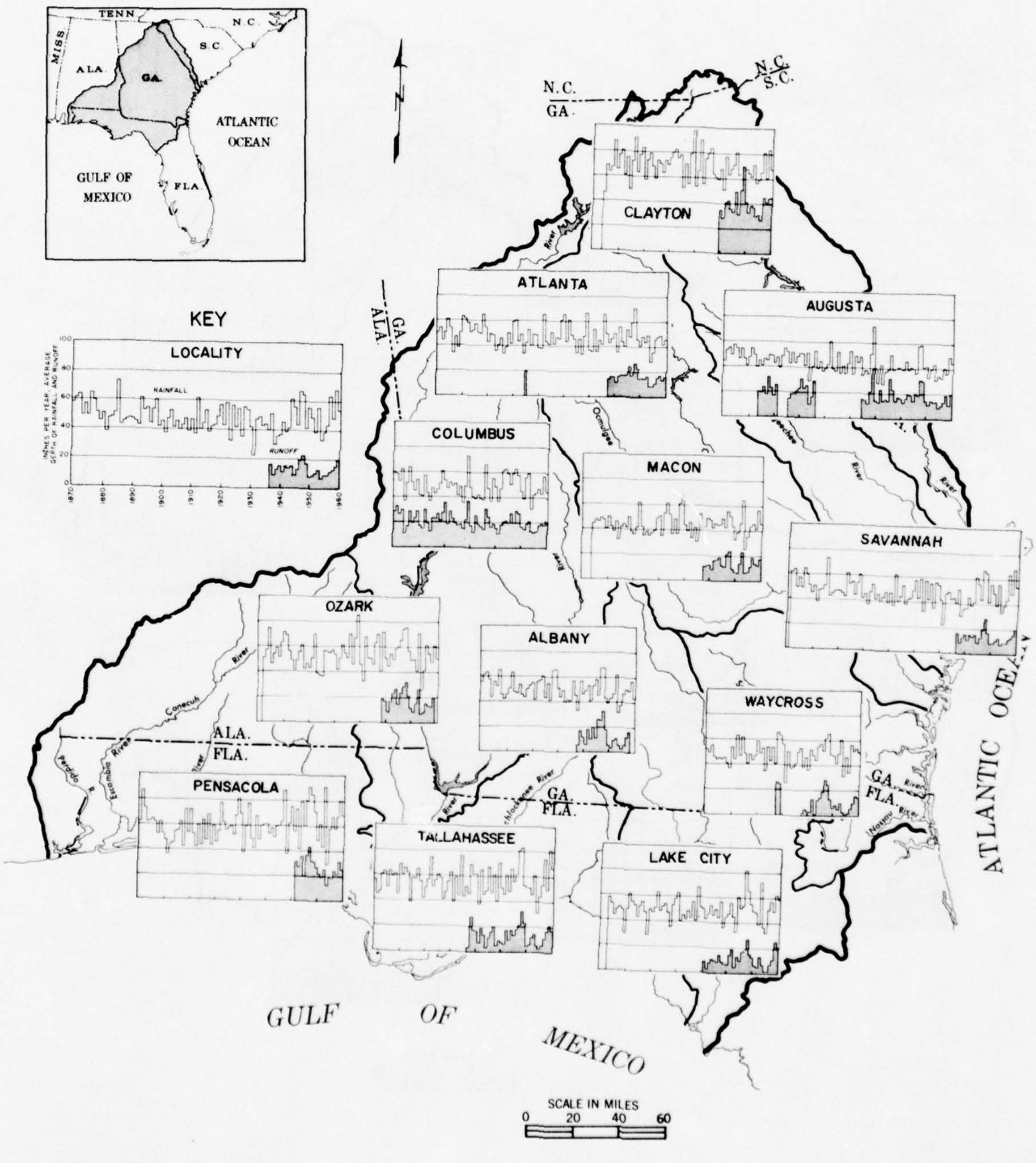


Figure 2.3

year to year is illustrated in the stepped lines in the diagrams of Figure 2.3. It may be noted that extremes of 50 percent more and 50 percent less than average have occurred in most records. Significantly, the annual rainfall is rarely less than the United States average of 30 inches.

SECTION II – DAMAGING STORMS

Hurricanes

While hurricanes usually bring rain at the driest time of year, they commonly cause destruction—partly from wind and waves but mostly from flooding. The flooding is due to runoff from heavy rain and, bordering the coast, to a combination of runoff and high storm tides. While the path of a hurricane is usually marked by the trajectory of its center of low pressure, the effects extend many miles in all directions. The center of a typical hurricane may travel at an average speed of 10 miles per hour, yet the speed of the air circulating about this center commonly exceeds 100 miles per hour over vast areas. For a tropical storm to be classified as a hurricane, the wind must be at least 75 miles per hour somewhere in the storm. A typical hurricane heads toward the North American continent from the south or southeast. As it approaches the continent, it usually curves to the north or northeast and may cross the coast anywhere from Mexico to Canada. Often, the storm turns northeast some distance from the coast and stays at sea with its effects brushing projecting places such as the Florida peninsula and Cape Hatteras, North Carolina. The map of Figure 2.5 shows by year the hurricanes which have entered the study area since 1910.

The map of Figure 2.4 shows the incidence of destruction caused by tropical storms—hurricanes plus lesser tropical storms—in terms of the frequency with which various parts of the study area have been visited by tropical storms. The lines on the map show the average number of years between such destructive storms. One year in three, for example, the coast between Pensacola and Apalachicola receives some damage. From the Fall Line north, lesser damage is caused on the average of once in 10 years or more.

Thunderstorms, Hail, and Tornadoes

The annual incidence of thunderstorms, which include lightning, ranges from 70 or 80 along the Gulf coast to 50 in the north and east portions of the Southeast River Basins. Most of the United States has fewer thunderstorms than the study area but the Florida peninsula has more. Most of the thunderstorms in the study area occur during summer afternoons. There is a good chance of at least one thunderstorm any month of the year.

The study area is particularly free from hail, most places averaging 1 to 2 days per year. Most of the United States has more, particularly the Midwest and Prairie States.

The study area averages about five tornadoes per year, each tornado affecting a small strip of area. This incidence of tornadoes is about the average for the eastern seaboard. In the United States, the incidence ranges from practically zero along the west coast to about twice the study area average for equivalent areas in the Prairie States. In the study area, tornadoes occur most frequently in the early spring.

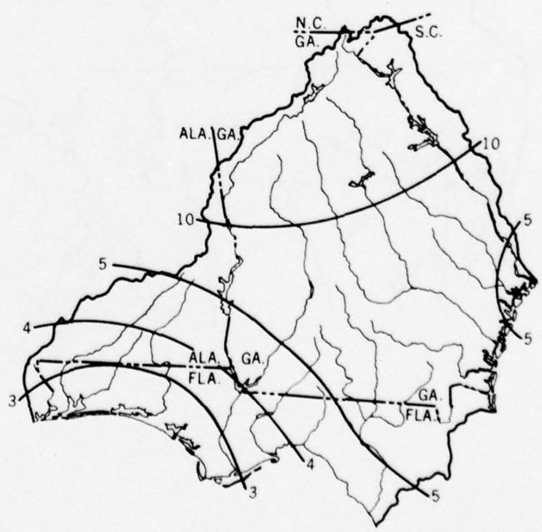


Figure 2.4 *Incidence of Hurricane Damage, Interval Shown in Years.*

HURRICANES ENTERING SOUTHEAST RIVER BASINS
1910-1960

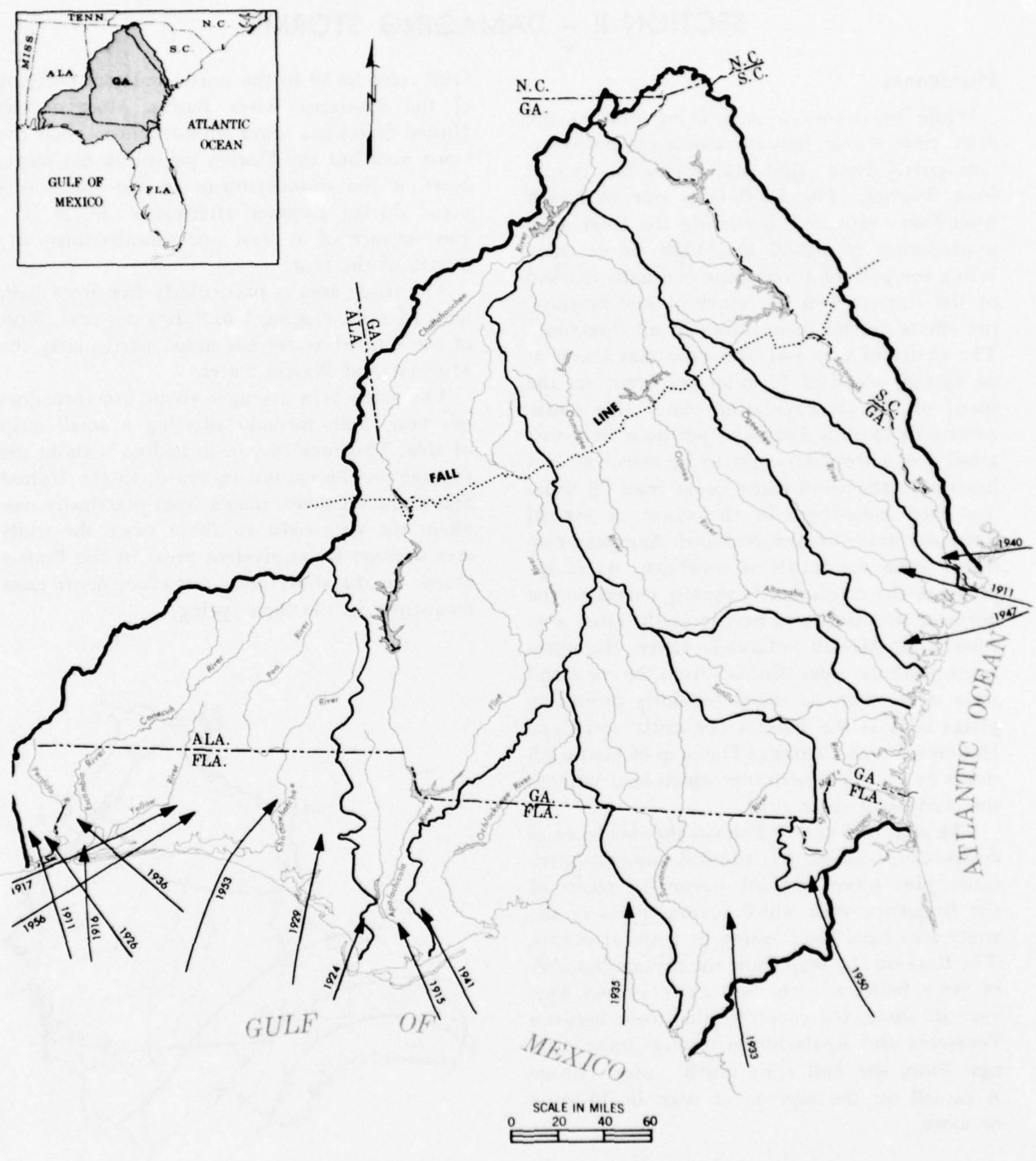


Figure 2.5

SECTION III – TEMPERATURE

Average and Seasonal Distribution

The curved lines in the diagrams on the map of Figure 2.2 show the seasonal distribution of average daily temperature in degrees Fahrenheit at selected representative stations. In general, the average daily temperature at the height of summer is slightly above 80°. July temperatures averaging about 75° are typical of most of the United States. Values less than 70° prevail in the extreme northern United States, a narrow fringe along the north Pacific coast, and in high mountain regions. Values considerably higher than 80° occur in parts of the Southwest.

In January, the average daily temperature in the study area is about 40°F. in the mountains, 45° over much of the Piedmont province, and 50° over much of the Coastal Plain.

Winter temperatures vary more over the United States than summer temperatures do. Average January temperatures range from zero over the northern plains to 70°F. at the southern tip of Florida. In the midwest and northeastern industrial belt, average January temperatures range from 20° to 30°.

Daily Range of Temperature

The average daily temperature range is about 20°F., with the minimum usually at sunrise, and the maximum usually early in the afternoon. Exceptions to this regime occur, of course, with a frontal passage and a change in air mass; strong wind and mixing; and dense clouds. With unusually long duration of cloudiness or with dense clouds, the daily temperature range may be less than 10°; and with clear skies, dry air, and light wind the range frequently exceeds 30°.

Figures 2.6 through 2.9 show the average daily extremes of temperature for January and July, for the period 1931-55, from the Weather Bureau publication, "Climates of the States." Figure 2.6 shows that on an average January day the temperature rises to more than 50°F. in the mountains, the low 60's in the central part of the study area, and reaches 70° in the extreme southeast part. As shown on Figure 2.7, the minimum temperature during an average January day is 30° in the mountains, 40° in the central part, and nearly 50° in the extreme southern portion of the Southeast River Basins.

In July, as shown on Figure 2.8, the average daily maximum temperature is about 90°F. over most of the Southeast River Basins, and somewhat less in the mountains. Figure 2.9 shows that during a typical July night the temperature falls to about 70° over most of the Southeast River Basins. In the mountains the minimum is about 60°, and along both coasts it is in the low 70's.

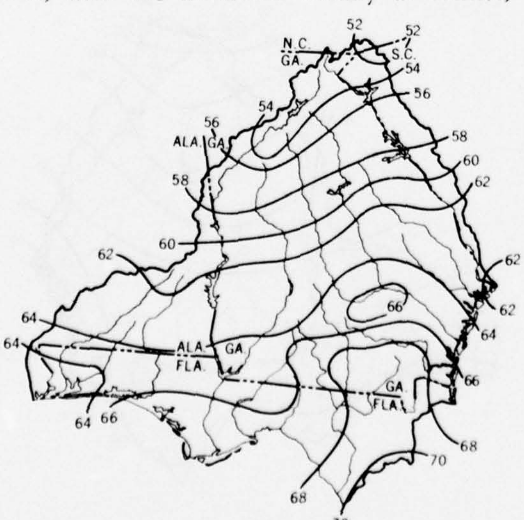


Figure 2.6 *Average January Maximum Daily Temperature, °F.*

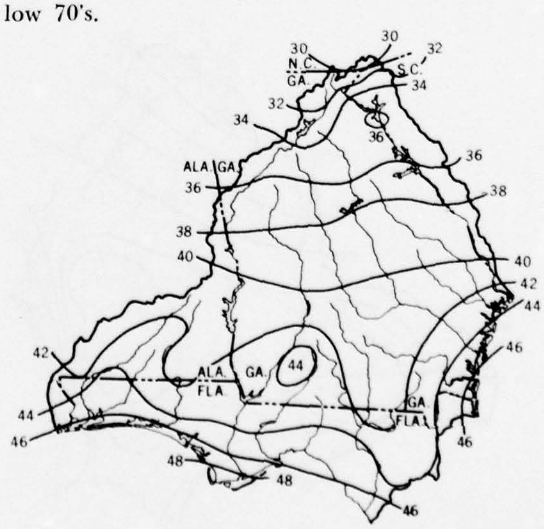


Figure 2.7 *Average January Minimum Daily Temperature, °F.*

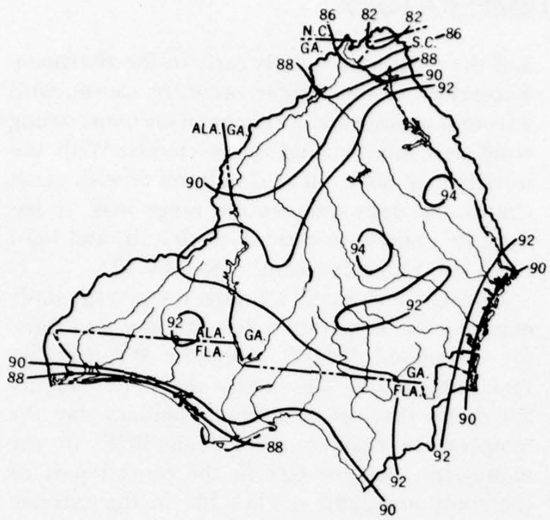


Figure 2.8 *Average July Maximum Daily Temperature, °F.*

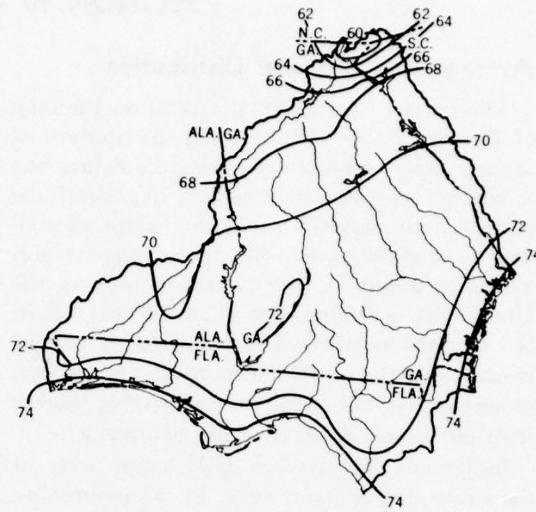


Figure 2.9 *Average July Minimum Daily Temperature, °F.*

Extremes of Temperature

The incidence of extreme temperatures in the Southeast River Basins is shown on Figures 2.10 and 2.11. Figure 2.10 shows the average number of days having a maximum temperature of 90° F. or more, and Figure 2.11, the average number of days having a minimum of 32° or less. The maps in these two figures do not show local variations related to sharp differences in topography.

The yearly temperature variation at most stations is small, two-thirds of the years having average annual temperature within one degree of the average. However, for shorter periods, such as a month, considerable departures from average occur. For example, February is occasionally warmer than March of the same year. Temperatures much higher than 100° F. and lower than zero are extremely rare anywhere in the Southeast River Basins.

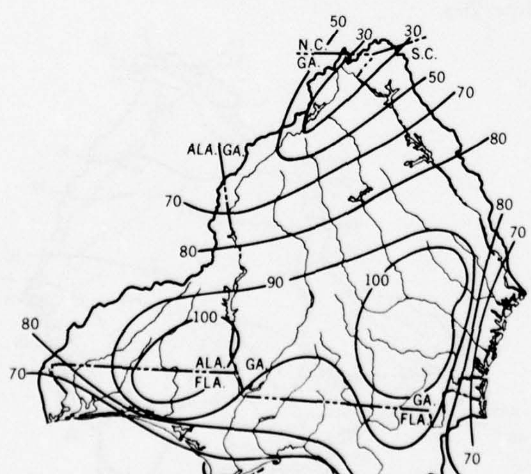


Figure 2.10 *Average Annual Number of Days with Maximum Temperature 90° F. or Higher.*

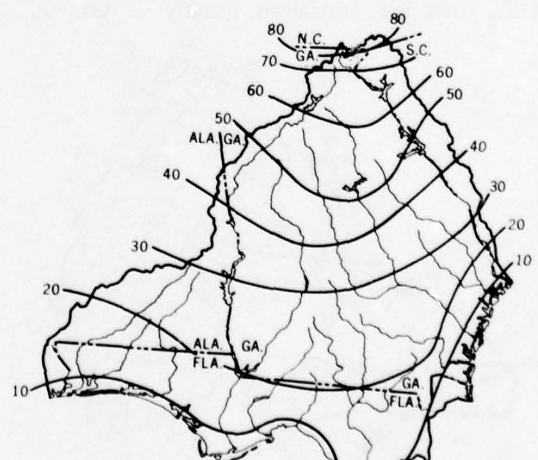


Figure 2.11 *Average Annual Number of Days with Minimum Temperature 32°F or Lower.*

Growing Season and Degree Days

Growing season is defined as the period between the last occurrence in spring and the first occurrence in autumn of temperatures below a given base. This base is different for different plants, some being much hardier than others. Tomatoes are damaged at temperatures below 32° F., whereas peas and cabbage can withstand temperatures as low as 24° for brief periods. Figure 2.12 shows the average frost-free period or length of growing season for sensitive plants. The number of days ranges from 180 in the mountains to 300 in the extreme south, with most of the Southeast River Basins having about 250. These values vary, of course, from year to year. In the north, the length of growing season is within 20 days of the average two-thirds of the years, and in the south it is within 30 days two-thirds of the years.

Figure 2.13 shows the average date of the last freeze in spring, and Figure 2.14 shows the average date of the first freeze in autumn. Both figures apply to sensitive plants. For hardy plants the average growing season limits would be about 25 days earlier in spring and about 20 days later in autumn.

The average annual number of degree-days below a base of 65°F. is a commonly used measure of requirement for heating buildings. In the Southeast River Basins this number averages 1,400 along the coasts, 2,400 for Augusta, and 2,800 for Atlanta and Columbus. For comparison, Phoenix, Los Angeles, and New Orleans have 1,200 to 1,500 degree-days; St. Louis and Seattle have about 4,500; and Boston, Chicago, and Denver have from 5,800 to 6,300 degree-days.

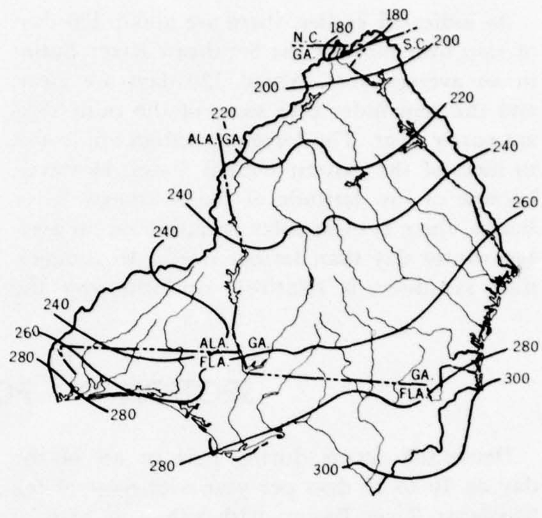


Figure 2.12 *Growing Season, Average Number of Days Per Year.*

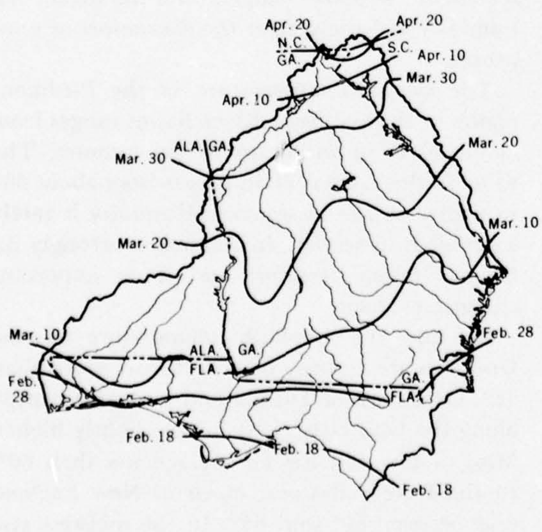


Figure 2.13 *Average Date of Last Spring Freeze.*

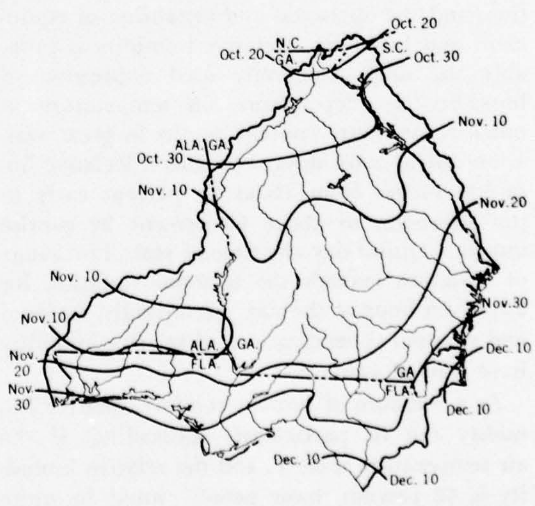


Figure 2.14 *Average Date of First Freeze in Fall.*

SECTION IV – SUN AND CLOUDS

As indicated earlier, there are about 120 days of rain over most of the Southeast River Basins in an average year. About 120 days are clear, and the remainder plus some of the rainy days are partly clear. The foregoing values apply also to most of the eastern United States. However, because of low latitude of the Southeast River Basins, there is more solar radiation on an average winter day than farther north. In summertime sunniness is relatively uniform over the United States and is generally adequate everywhere.

Partly because of the cloudiness associated with summer shower activity in the Southeast, June and July frequently have no more hours of sunshine than May. This summer afternoon cloudiness, along with the proximity of most of the Southeast River Basins area to the relatively cool ocean, helps explain why temperatures much above 100°F. are extremely rare.

SECTION V – FOG AND HUMIDITY

Dense fog occurs during part or all of the day on 10 to 15 days per year over most of the Southeast River Basins, with values as high as 20 along part of the Gulf coast and 30 in the extreme north mountains. Along both northern coasts of the United States 30 or more days of dense fog occur in an average year. Most of the Appalachian region has 30 or more foggy days per year. Practically all the rest of the United States has less than 30 days of fog per year, and most of the United States has less than 10.

Extremes and changes in atmospheric humidity affect human comfort, manufacturing processes, air-conditioning load, growth of vegetation, and the operation and durability of equipment and buildings. Relative humidity is probably the most commonly used expression of humidity. Its dependence on temperature as much as on water content results in great variation during most days everywhere. Relative humidity ranges from about 50 percent early in the afternoon to above 90 percent by sunrise during a typical day any time of year. This range of variation exceeds the seasonal variation for any given hour of the day. Accordingly, regional and seasonal generalizations of relative humidity have limited value.

As a measure of human comfort, relative humidity can be particularly misleading. If the air temperature is 68°F. and the relative humidity is 62 percent, most people would be quite comfortable; but if the air temperature is 90° and the relative humidity is only 50 percent, many people would be uncomfortable. The wet-bulb temperature is about 60° in the first case and 75° in the second case. Also, the amount of water vapor is much greater in the second case, despite the lower relative humidity.

As a measure of human comfort, humidity can conveniently and effectively be described in terms of the wet-bulb temperature. The wet-bulb temperature is the temperature of a moist, ventilated, shaded thermometer bulb at which there is an exact balance between the warmth of the air and the evaporational cooling effect of the moist surface of the bulb. In general, the higher the wet-bulb temperature, the higher the humidity and the greater the discomfort of most people.

The wet-bulb temperature in the Piedmont region of the Southeast River Basins ranges from about 40°F. in winter to 70° in summer. The value in the Coastal Plain ranges from about 50° in winter to 75° in summer. Humidity is rarely a problem in winter. In summer it strongly influences human comfort and is an important climatic element.

In July the wet-bulb temperature in the United States ranges from 50°F. to more than 75°. Over most of Florida and a narrow margin along the Gulf coast, it is 75° or slightly higher. Most of the west has an average less than 60°. In the Lake States and much of New England it is between 60° and 65°. In the midwest and much of the Atlantic seaboard it is between 65° and 70°.

SECTION VI – WIND

The Southeast River Basins is at the southern edge of the prevailing westerlies and north of the usual trade-wind belt. The path of the westerlies migrates southward in winter and occasional storms of that season are associated with the westerlies. In summertime the westerlies are generally north of the Southeast River Basins. In addition to the general circulation, the Southeast River Basins area is subject at times to the more local circulation within storms, to mountain-valley breezes, and to land-sea breezes near the ocean and gulf.

In general, the wind near the ground has variable direction and is relatively light. The average speed is 5 to 10 miles per hour with no well-defined directional pattern either for average or for strong winds. Because of the relatively brief and rare occurrence of hurricanes and tornadoes they have but little effect on the average wind pattern of most of the Southeast River Basins. In general, the windiest season is early spring, with lighter winds in summer, averaging about 2 miles per hour difference between the two seasons.

Physiographic influences in the Southeast River Basins are important. Stations such as Pensacola and Savannah, which are at or near the open coast, have average wind speeds of 7 to 10 miles per hour; stations, such as Atlanta, on ridges or plateaus have average wind speeds of 8 to 10 miles per hour; and at relatively sheltered valley stations such as Augusta, Macon, and Tallahassee the winds average 5 to 7 miles per hour.

SECTION VII – TIDES

Normal gravitational tides in the Southeast River Basins occur twice daily. The tidal range, which is the difference between mean high water and mean low water, increases from about 5 feet near the mouth of the Nassau River to 7 feet near Savannah along the Atlantic coast. Along the Gulf of Mexico the tidal range increases from about 1 foot near Pensacola to more than 2 feet near the mouth of the Suwannee River. Departures from the general trend along each coast amount to as much as one-half foot at some places because of local configuration of bays, sounds, and harbor entrances.

Extreme low water is generally about 1 to 4 feet below mean low water, the distance usually being about half the tidal range. Extreme high tides as much as 20 feet above mean sea level may result from hurricane winds and pressures, and river floods may also produce high stages in estuaries.

SECTION VIII – OBSERVATION STATIONS

The maps of Figure 2.15 to Figure 2.23 show the locations of precipitation, temperature, streamflow, and other hydrologic stations as of 1960 for individual basins in the study area. These maps appear in geographical order of the individual basins from northeast to southwest across the study area. For additional and more detailed information, reference may be made to publications of the agencies responsible for the observations or to the maps from which these figures were prepared and which are identified as "River Basin Maps of the Inter-Agency Committee on Water Resources Subcommittee on Hydrology—Prepared under supervision of U. S. Weather Bureau—1960." The list of symbols, shown on Figure 2.15 for all maps in the series, was reproduced from the original Inter-Agency Committee maps and shows some types of observations which are not taken in every part of the country.

HYDROLOGIC OBSERVATION STATIONS

SAVANNAH BASIN

Figure 2.15

HYDROLOGIC OBSERVATION STATIONS

OGEECHEE BASIN

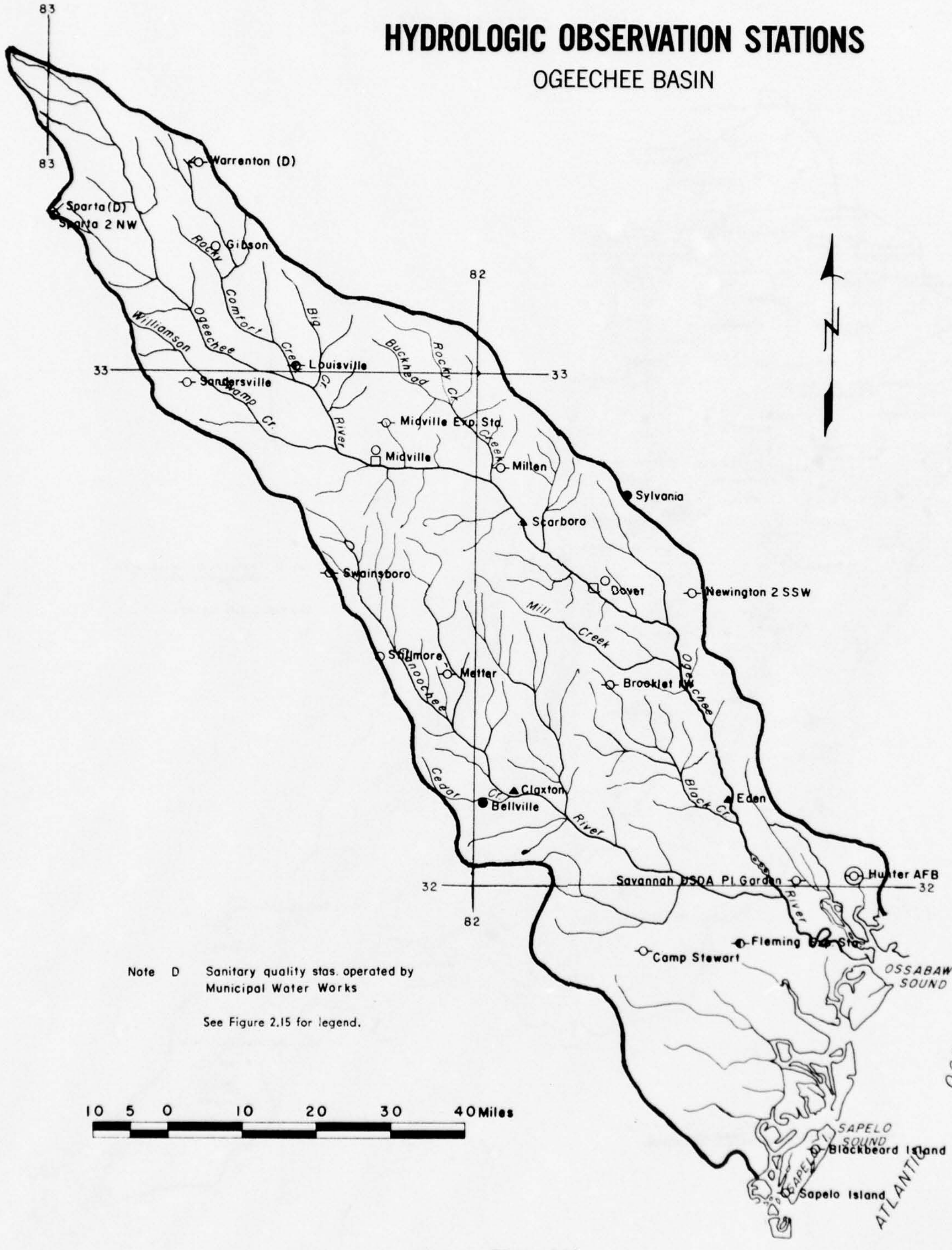


Figure 2.16

HYDROLOGIC OBSERVATION STATIONS

ALTAMAHA BASIN

Figure 2.17

HYDROLOGIC OBSERVATION STATIONS
SATILLA-ST. MARYS BASINS

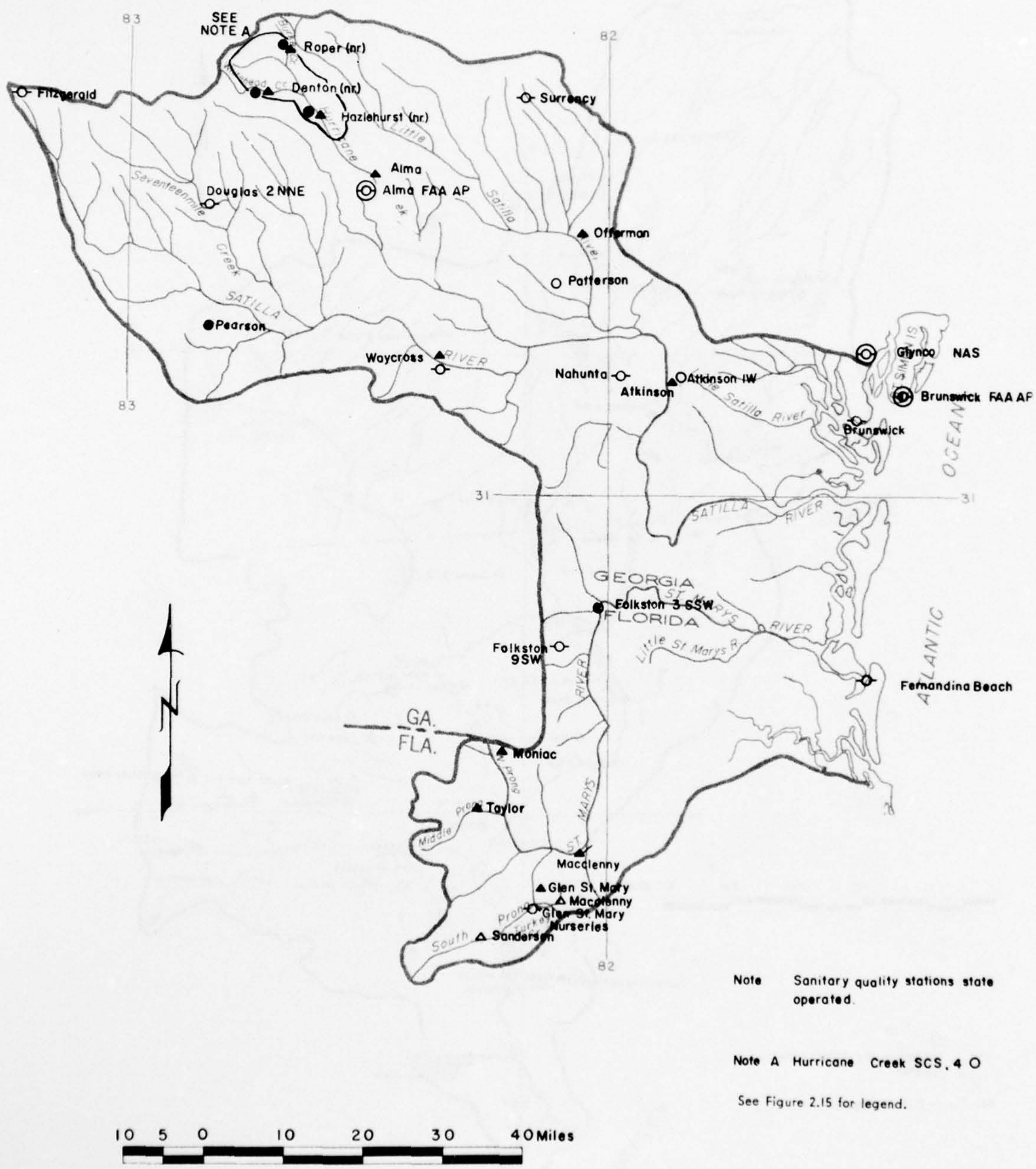


Figure 2.18

HYDROLOGIC OBSERVATION STATIONS
SUWANNEE BASIN

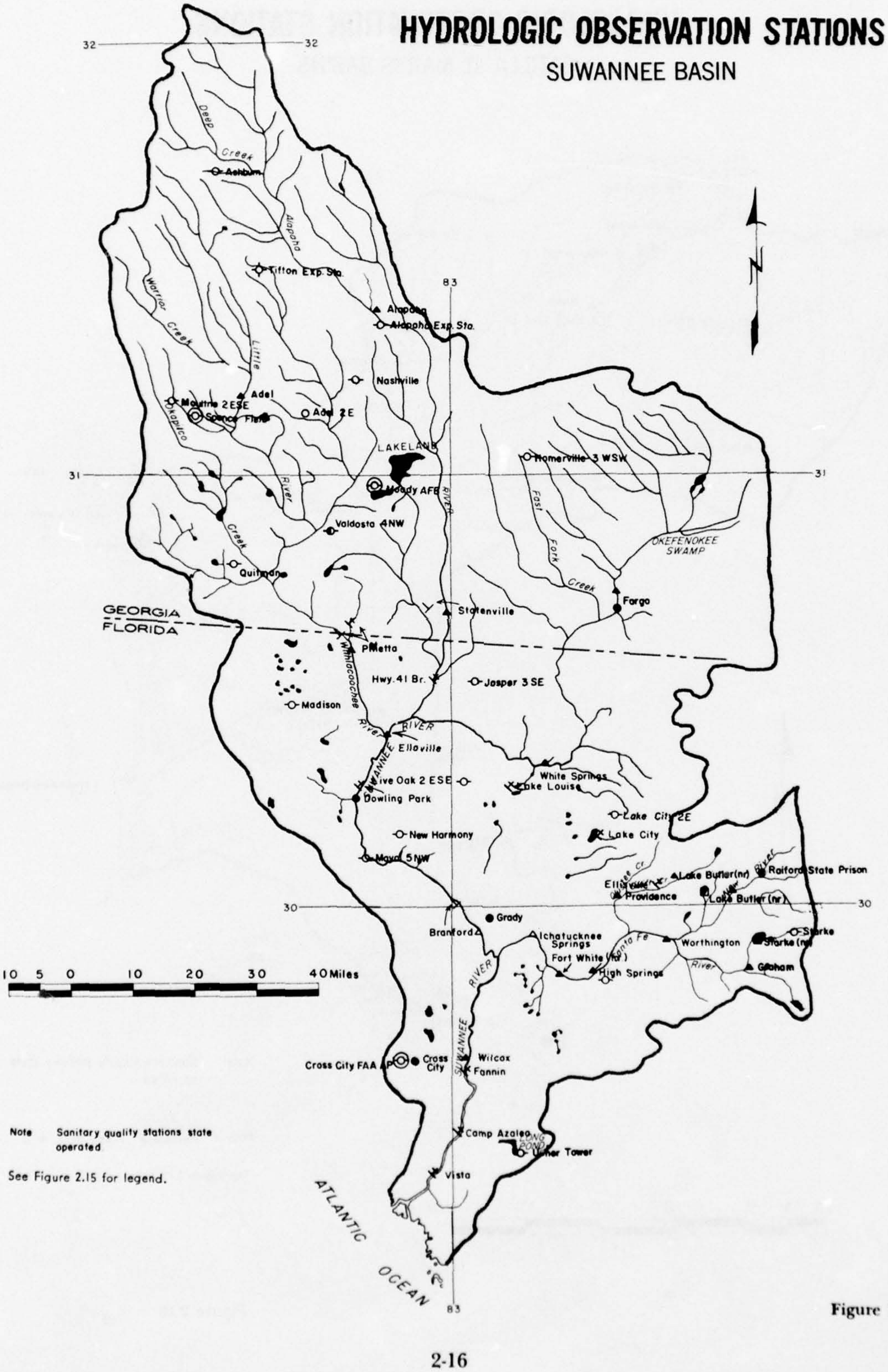


Figure 2.19

HYDROLOGIC OBSERVATION STATIONS

OCHLOCKONEE BASIN

Figure 2.20

HYDROLOGIC OBSERVATION STATIONS
APALACHICOLA-CHATTAHOOCHEE-FLINT BASINS
NORTH PORTION

Note A Buford Dam 3 ■, (1 Pool, 2 Tail)
Note C 2 add ◇ Within 1/4 mile radius in connection with same project at Univ. of Ga. Exp. Sta.
Note D Sanitary quality stas. operated by Municipal Water Works.
Note E Sanitary quality stas. operated by PHS National Water Quality Network.
Note F Sanitary quality stas. operated by Tennessee Valley Authority
Note G Sanitary quality stas. operated by West Point Mfg. Service Div.
Note Unless otherwise indicated sanitary stas. operated by state.

See Figure 2.15 for legend.

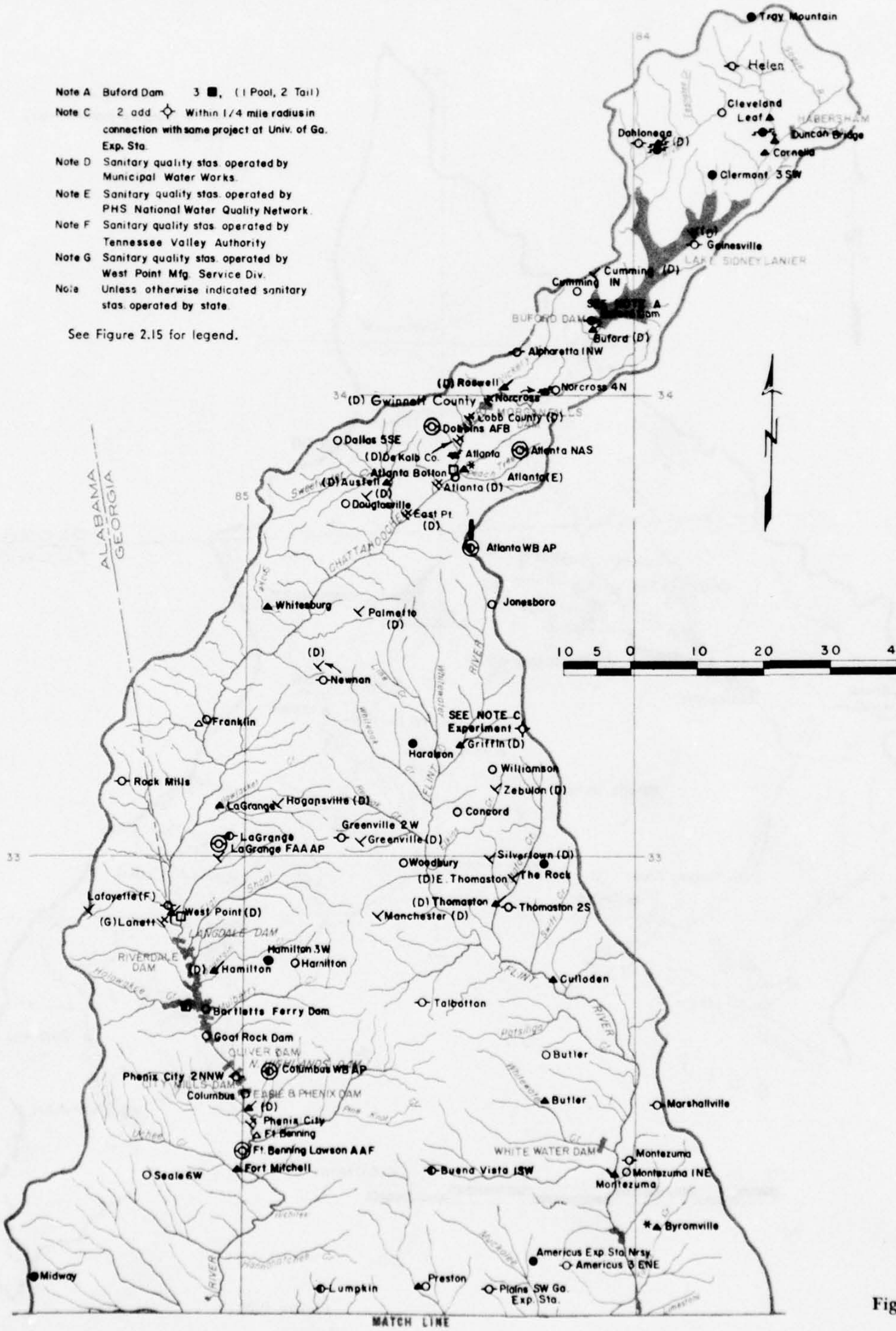


Figure 2.21

HYDROLOGIC OBSERVATION STATIONS
APALACHICOLA-CHATTAHOOCHEE-FLINT BASINS
SOUTH PORTION

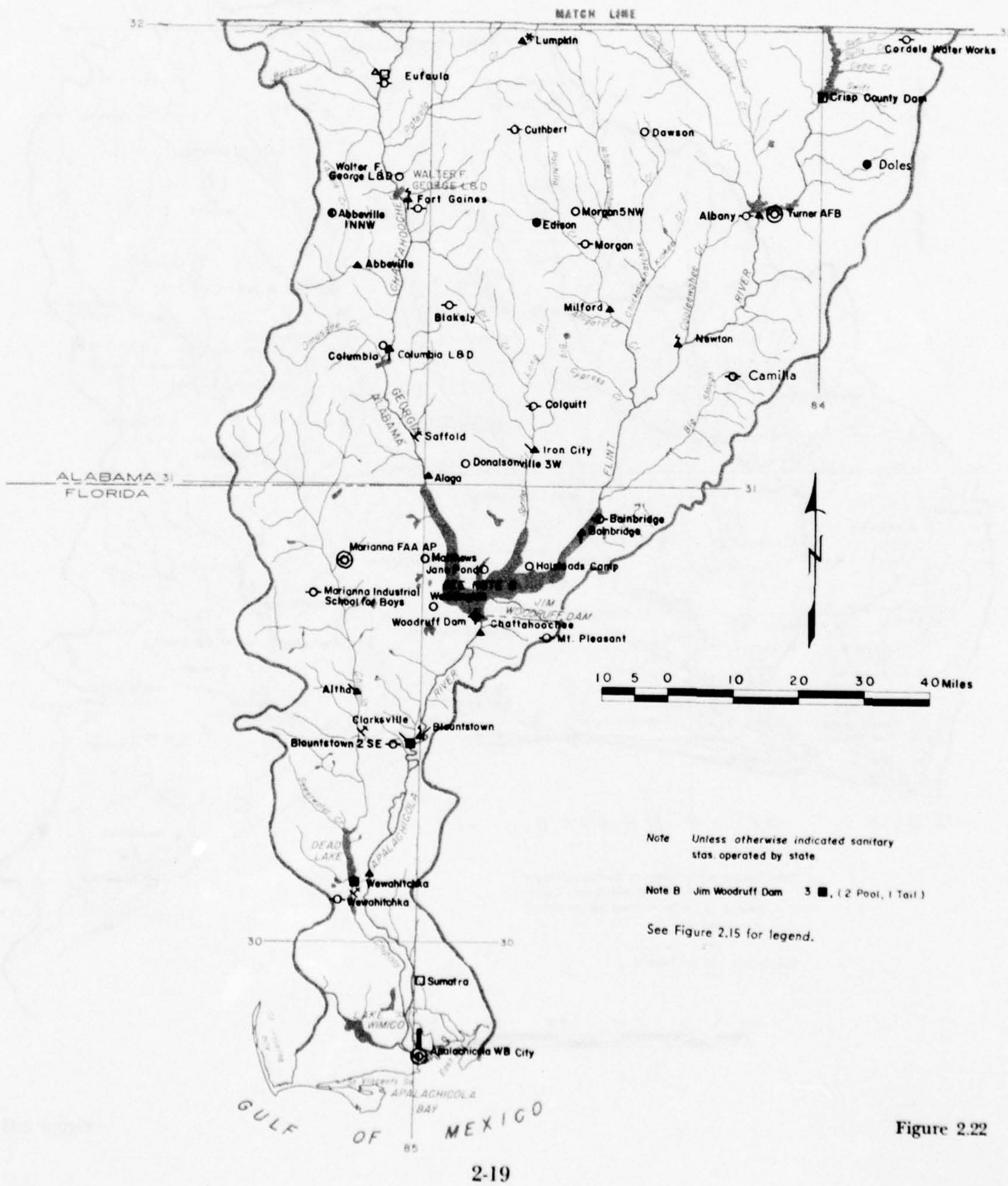


Figure 2.22

HYDROLOGIC OBSERVATION STATIONS

CHOCTAWHATCHEE-PERDIDO BASINS

Note: Sanitary quality station at Century, Florida operated by P H S National Water Quality Network. All other sanitary quality stations state operated.

See Figure 2.15 for legend.

Figure 2.23

PART THREE – WATER RESOURCES AND PROBLEMS

SECTION I – SURFACE WATER

Average Streamflow

The average annual streamflow of the Southeast River Basins represents about 15 inches average depth over the drainage area, compared to the United States average of about 8 inches. Wet years include 1929 and 1948 and the outstanding recent dry period is 1954-56. Most of the stream-gaging records were started in 1937 or later and most of the older records have discontinuities, so estimates of average flow are not precise. Flow postulated for future years is largely a product of the conventions chosen in any selection of (1) a standard period of record; (2) methods for adjusting short records to the older ones; (3) estimates for ungaged areas; and (4) the assumption of no long-term trends or cycles to be extrapolated. Streamflow for the period 1937 through 1955 was taken as a sufficiently good indicator of the streamflow regime to be expected for the period ending in the year 2000.

On Figure 3.1, the wide, shaded bands along each major river indicate, by the scale shown, the average annual streamflow or runoff for the standard period 1937-55. The narrow, heavily shaded bands indicate the lowest calendar month flow during the period. This figure shows the relative flows of the major streams and the accumulated flow from tributaries. Figure 3.2 shows the average annual runoff for the period 1937-55 from areas of 24 to 1,300 square miles for the purpose of indicating the geographical distribution of surface runoff. Larger drainage areas than those shown would obscure local variations in average runoff. Data for smaller areas are very sparse. Runoff from the intervening ungaged areas can be interpolated fairly well above the Fall Line and isolines of average annual runoff could be drawn for the portions of the Southeast River Basins in the Piedmont and Blue Ridge provinces. However, below the Fall Line, the drawing of such lines would be largely conjecture because of discontinuities in geologic and soil-mantle conditions which affect the regional distribution of surface runoff more than rainfall does in much of this area. In the absence of a generalized regional study of ground water, rainfall, runoff, and related factors, it has been necessary to estimate runoff from ungaged areas by such methods as assuming that characteristics believed to apply in a nearby gaged area apply to the area for which estimates are needed. In some places, such as Savannah headwaters, it was necessary to extrapolate instead of interpolate. The map of Figure 3.2 shows the regional runoff pattern in a general way.

Withdrawals of Surface Water

The average annual surface water discharge to the sea from the study area is about 70 million acre-feet and the lowest flow of record half that. The 1960 withdrawals from surface sources totaled 3 million acre-feet and the projected withdrawals for the year 2000 total 9 million acre-feet, not counting reuse. These withdrawals will be widely dispersed. Possibly one-tenth of the total withdrawal will be consumed.

Seasonal Distribution of Streamflow

The diagrams on the map of Figure 2.2 show the seasonal distribution of average monthly streamflow in inches average depth for selected drainage areas near the cities shown on the map by means of shaded bars at the bottom of each diagram. Regardless of variations in the seasonal rainfall pattern, the average streamflow, except in certain coastal areas, is high in early spring and recedes to a low in late autumn. This average seasonal regime is typical even of most small streams. The summer rainfall peak does not ordinarily produce a summer runoff peak because summer showers usually fall on relatively dry soil and because much moisture is transpired by vegetation in summer, thus leaving relatively little contribution to runoff. Some of the coastal streams originating in large springs or lakes tend to have fairly uniform flow throughout the year.

STREAMFLOW

AVERAGE ANNUAL AND LOW FLOW

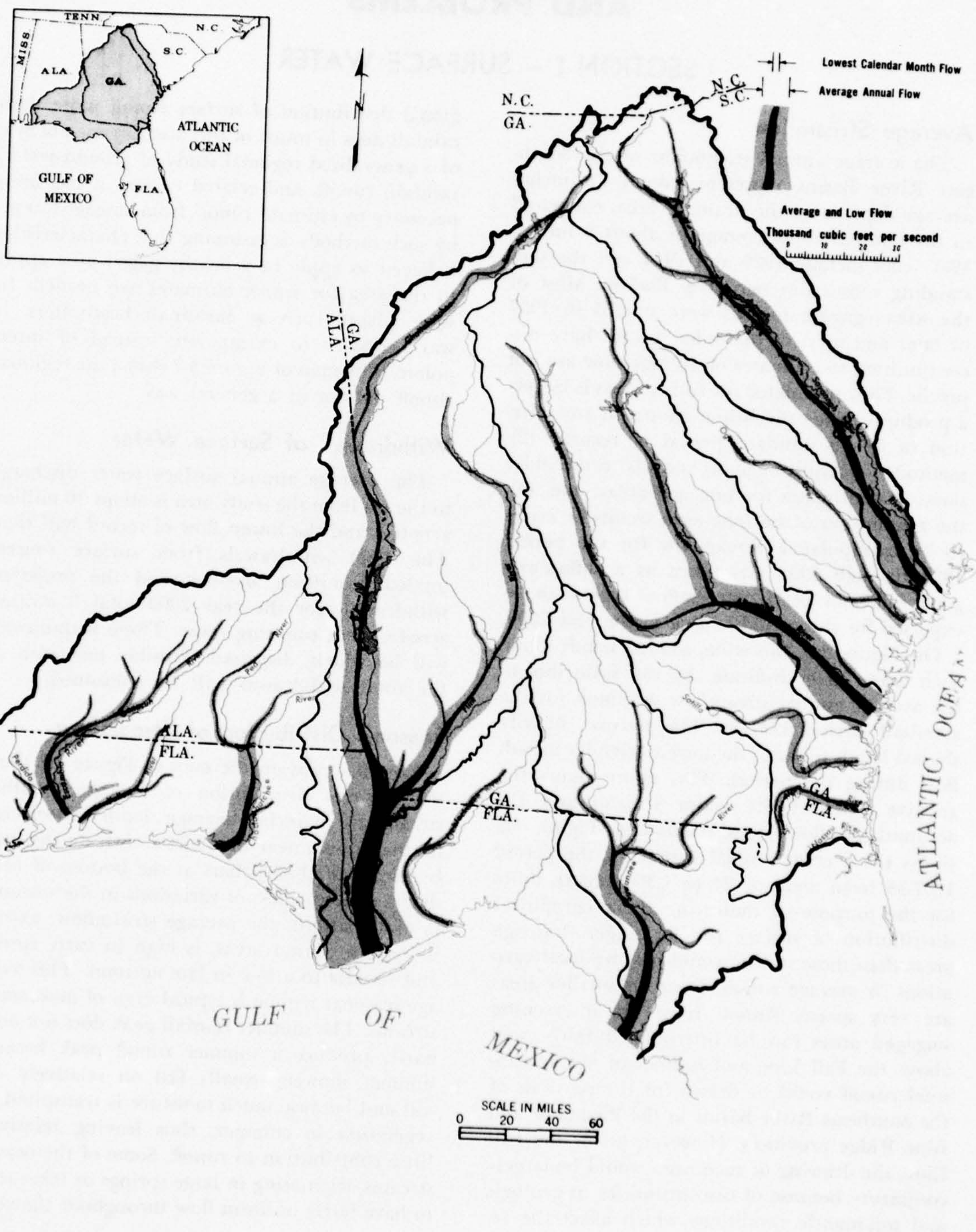


Figure 3.1

AVERAGE ANNUAL RUNOFF IN INCHES

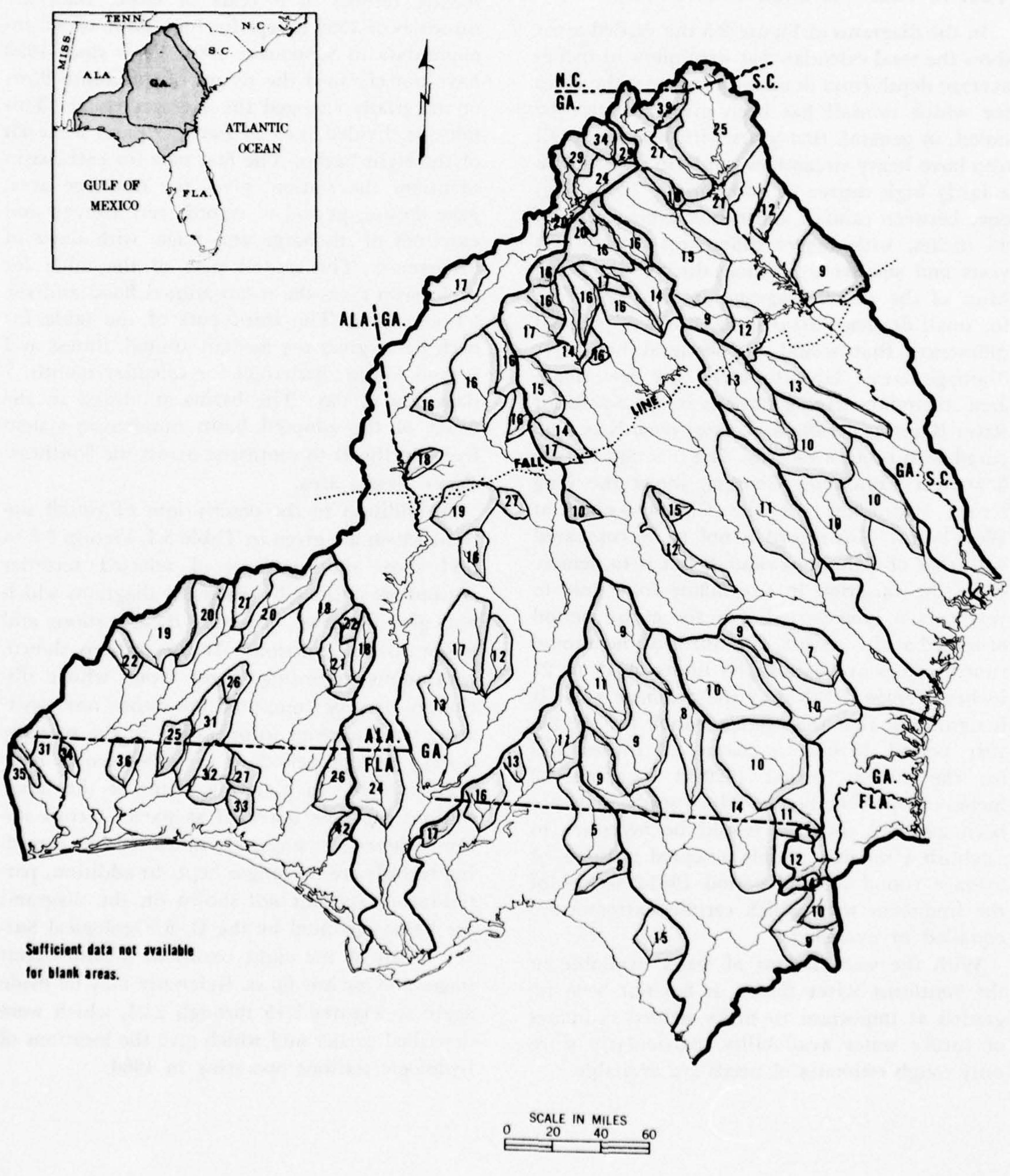


Figure 3.2

A few of the others tend to have two rises per year, one following each rainy season, because of special local geological and vegetative conditions.

Year-to-Year Variation in Streamflow

In the diagrams of Figure 2.3 the shaded areas show the total calendar-year streamflow in inches average depth from drainage areas near the cities for which rainfall has been given. It may be noted, in general, that years with heavy rainfall also have heavy streamflow, and vice versa, with a fairly high degree of correlation. The difference between rainfall and runoff averages about 35 inches, with bigger differences during wet years and smaller differences during dry years. Most of the runoff diagrams in this figure are for small drainage areas so as to reflect regional differences that would be obscured by larger drainage areas. Unfortunately, the few small-area streamflow gaging stations in the Southeast River Basins generally have short records as compared with rainfall records. The diagram for the flow near Columbus, Georgia, shows the long record streamflow for the Chattahoochee at West Point. This record is not to be compared with that of Columbus rainfall but is to demonstrate the variation in streamflow from year to year over a long period. For the entire period of record at this station, two-thirds of the annual runoff values are within the limits of 15 to 27 inches average depth over the drainage area. It is significant that the average runoff for the 20-year period 1940-59 is about 19 inches and for the 20-year period 1920-39 is about 22 inches—15 percent higher. More study than has been afforded thus far would be necessary to establish a reliable, widely accepted estimate of average runoff for the period 1961-2000, or of the frequency with which certain extremes are equalled or exceeded.

With the vast amount of water available in the Southeast River Basins, it has not been regarded as important to make refined estimates of future water availability, particularly since only rough estimates of needs are available.

Streamflow Frequencies and Extremes

Table 3.1, prepared by the U. S. Geological Survey, gives average discharge, high and low extremes of discharge and stage, and generalized frequencies of high and low flows for stations having records of 5 years or more. Data are shown as of 1958 except for high flows which include data to September 1961. Years since 1958 have not changed the record of minimum flows or materially changed the average regime. This table is divided into 24 parts, 3 parts for each of the eight basins. The first part for each basin identifies the station, gives the drainage area, gage datum, period of record, and average and extremes of discharge and stage, with dates of occurrence. The second part of the table for each basin gives the mean annual flood and the 50-year flood. The third part of the table for each basin gives the median annual, lowest and second lowest discharges for calendar month, 7 days, and 1 day. The basins are listed in the order of the adopted basin numbering system from northeast to southwest across the Southeast River Basins area.

In addition to the descriptions of runoff stations which are given in Table 3.1, Figures 3.3 to 3.11 show the locations of selected recorder streamflow stations by schematic diagrams which also give the river miles for these stations and major stream junctions. At the stations shown, continuous recording gages from which discharges may be computed are either now operating or have been in operation in the past for a long enough period so that the records have been valuable in planning. Some of the latter stations are now operated as partial-record stations where crest stages are measured but recording records are no longer kept. In addition, partial-record stations not shown on the diagrams are being operated by the U. S. Geological Survey in all of the eight basins to measure crest stages and/or low flows. Reference may be made again to Figures 2.15 through 2.23, which were described earlier and which give the locations of hydrologic stations operating in 1960.

TABLE 3.1

Streamflow Data for Southeast River Basins by Basins

Basin 1 — **Average and extreme discharges at gaging stations in Savannah basin**

Gaging station	Drainage area (sq. mi.)	Gage datum (ft. above m.s.l.)	Period of record (water years)	Average discharge			Minimum daily discharge			Period of known floods (water years)	Maximum stage and discharge		
				C.f.s.	Inch	Number of years	C.f.s.	Stage (ft.)	Date		Date	Stage (ft.)	Discharge (c.f.s.)
Chattooga River near Clayton, Ga.	207	1,165.6	1907-08, 1940-58	592	38.82	19	88	0.7	Oct., 1954	1917-61	8/30/40	13.8	29,000
Chattooga River near Tallulah Falls, Ga.	256	960	1917-29	840	44.52	13	96	0	Sep., 1925	1917-29	8/15/28	16.4	22,400
Panther Creek near Toccoa, Ga.[1]	32.5	673.53	1943-58	68.8	28.78	16	10	1.4	Sep., 1955	1927-61	6/16/49	18.0	15,100
Tugaloo River near Madison, S. C.	593	630.10	1898-1902, 1903-10	2,057	47.12	9	435	1.4	Oct., 1904	[2]	[2]	[2]	[2]
Tugaloo River near Hartwell, Ga.[3]	909	570	1925-27, 1940-58	[4]1,935	28.91	20	188	1.4	Oct., 1954	1940-60	8/31/40	10.8	28,600
Whitewater River at Jocassee, S. C.	47.3	777.79	1951-58	163	46.81	7	24	1.6	Oct., 1954	1951-61	3/11/52	11.17	7,120
Keowee River near Jocassee, S. C.	148	737.43	1950-58	446	40.93	8	57	0.9	Oct., 1954	1949-61	3/11/52	16.23	18,400
Keowee River near Newry, S. C.[5]	455	625.00	1940-58	1,131	33.77	19	152	1.8	Oct., 1954	1939-61	8/13/40	[6]24.60	25,200
Seneca River near Anderson, S. C.[5]	1,026	520	1928-58	2,006	26.56	30	170	2.4	Sep., 1931	1928-61	8/17-18/28	25.73	81,100
Savannah River near Iva, S. C.	2,231	432.255	1950-58	3,986	24.27	9	540	1.9	Oct., 1954	1950-61	3/12/52	12.74	54,400
Rocky River near Calhoun Falls, S. C.	267	403.04	1950-58	238	12.11	8	9	0.6	Sep., 1954	1950-61	3/25/52	9.44	9,450
South Beaverdam Creek at Dewy Rose, Ga.	35.8	581.07	1943-58	48.5	18.39	16	1.0	0.8	Sep., Oct., 1954	[2]	8/25/1852 8/25/08	23.6	[2]
Do.										1943-61	1/18/43	13.4	2,600
Savannah River near Calhoun Falls, S. C.[7]	2,876	363.53	1896-1901, 1903-04, 1930-32, 1938-58	4,887	23.08	23	636	0.5	Oct., 1954	1896-1961	8/25/08	28.2	114,000
North Fork Broad River near Carnesville, Ga.	119	600.33	1943-45, 1954-58	144	16.42	6	17	1.9	Oct., 1954	1942-44 1955-61	2/21/61	14.6	11,400
Broad River near Carlton, Ga.	762	384.5	1897-1913	1,416	25.22	15	270	1.4	Sep., Oct., 1905	1898-1961	8/25/08	39.0	70,000
Broad River near Bell, Ga.	1,430	357.16	1927-32, 1937-58	1,658	15.75	27	110	2.2	Oct., 1954	1927-61	10/2/29	34.8	79,400
Little River near Mount Carmel, S. C.	217	353.97	1940-58	198	12.39	18	1.0	0.4	Oct., 1954	1940-61	8/14/40	29.60	20,800
Little River near Washington, Ga.	291	360	1950-58	206	9.61	9	0.32	1.6	Oct., 1954	1950-61	3/4/52	27.6	13,100
Little River near Lincolnton, Ga.	574	271.7	1943-51	512	12.11	7	15	1.0	Oct., 1944	1928-51	9/28/29	44.3	54,000
Savannah River near Clarks Hill, S. C.[8]	6,150	182.69	1940-54	[4]8,479	18.73	13	1,120	--	Jun., 1941	1940-61	8/14/40	29.34	196,000
Stevens Creek near Modoc, S. C.[5]	545	197.34	1930-31, 1940-58	351	8.75	19	0	--	Sep.,	1930-61	10/1/29	52.5	[2]
Do.									Nov., 1954	1940-61	8/14/40	[6]41.1	35,100
Savannah River at Augusta, Ga.[9]	7,508	97.00	1884-92, 1896-1907, 1925-51	10,630	19.23	44	1,040	--	Oct., 1927	1796-1951	1796	40	360,000
Do.										1876-1951	9/27/29	[11]46.3	343,000
Do.[10]							1,770	0.5	Oct., 1951	1952-61	4/18/58	22.91	66,300
Savannah River at Burtons Ferry Bridge near Millhaven, Ga.[9]	8,650	52.42	1940-51	10,870	17.07	12	2,120	1.5	Sep., 1951	1797-1951	10/ /29	30.8	220,000
Do.[10]	8,650	52.42	1952-58	[12]8,126	12.76	7	2,550	1.6	Oct., 1951	1952-61	4/22/58	18.94	41,400
Brier Creek at Millhaven, Ga.[5]	646	95.88	1937-58	626	13.15	22	64	--	Sep., 1954	1797-1961	10/ /29	25.1	64,000
Savannah River near Clyo, Ga.[9]	9,850	13.41	1930-33, 1938-51	11,960	16.49	18	1,950	--	Sep., 1931	1797-1951	10/6/29	29.7	270,000
Do.[10]	9,850	13.41	1952-58	[12]9,134	12.60	7	3,140	1.3	Oct., 1951	1952-61	4/25/58	17.41	45,500

NOTES:
[1] Diversion above station at times for municipal supply of Toccoa, Ga.; average discharge adjusted for diversions.
[2] Not determined.
[3] Flow regulated by powerplants, by Burton Reservoir (completed 1920) and by Mathis Reservoir (completed 1914) (combined usable capacity, 129,000 acre-feet), on Tallulah River.
[4] Unadjusted for change in contents of reservoirs.
[5] Some regulation by powerplant produces diurnal fluctuation at low flow.
[6] Maximum stage occurred at different time than did maximum discharge.
[7] Maximum stage known, 28.2 ft. Aug. 25, 1908, original site and datum, from records of U.S. Weather Bureau; discharge and relation to present datum not determined.
[8] Prior to December 1951 some regulation by Burton and Mathis Reservoirs and powerplants above station; from December 1951 flow completely regulated by Clark Hill Reservoir, usable capacity 1,730,000 acre-feet.
[9] Prior to December 1951 some regulation by reservoirs and powerplants above station; some regulation by New Savannah Bluff Lock and Dam since 1937.
[10] Since December 1951 flow regulated by Clark Hill Reservoir, Stevens Creek powerplant, and New Savannah Bluff Lock and Dam.
[11] At site of Fifth Street gage at datum 102.06 ft. above mean sea level.
[12] Flow unadjusted for change in contents of Clark Hill Reservoir.

Flood characteristics of streams at gaging stations in Savannah basin

Gaging station	Mean annual flood[1]			Flood of 50-year recurrence interval[1]		
	Discharge		Stage (ft.)	Discharge		Stage (ft.)
	C.f.s.	C.f.s.m.		C.f.s.	C.f.s.m.	
Chattooga River near Clayton, Ga.	7,600	36.7	6.1	22,600	109	11.8
Chattooga River near Tallulah Falls, Ga.	11,000	43.0	10.7	32,700	128	--
Panther Creek near Toccoa, Ga.	3,450	106	8.3	10,200	314	14.7
Tugaloo River near Madison, S. C.	--	--	--	--	--	--
Tugaloo River near Hartwell, Ga.	18,200	20.0	8.8	54,100	59.5	--
Whitewater River at Jocassee, S. C.	3,170	67.0	6.5	--	--	--
Keowee River near Jocassee, S. C.	9,530	64.4	9.8	--	--	--
Keowee River near Newry, S. C.	18,600	40.9	20.2	--	--	--
Seneca River near Anderson, S. C.	23,500	22.9	13.3	--	--	--
Savannah River near Iva, S. C.	45,100	20.2	11.5	--	--	--
Rocky River near Calhoun Falls, S. C.	5,620	21.0	7.9	--	--	--
South Beaverdam Creek at Dewy Rose, Ga.	1,290	36.0	9.9	3,830	107	--

(continued)

TABLE 3.1—Continued

Gaging station	Mean annual flood[1] Discharge C.f.s.	Mean annual flood[1] Discharge C.f.s.m.	Mean annual flood[1] Stage (ft.)	Flood of 50-year recurrence interval[1] Discharge C.f.s.	Flood of 50-year recurrence interval[1] Discharge C.f.s.m.	Flood of 50-year recurrence interval[1] Stage (ft.)
Savannah River near Calhoun Falls, S. C.	46,500	16.2	7.6	138,000	48.0	--
North Fork Broad River near Carnesville, Ga.	3,300	27.7	6.9	9,800	82.4	--
Broad River near Carlton, Ga.	14,600	19.2	13.0	43,400	57.0	28.5
Broad River near Bell, Ga.	25,200	17.6	23.4	74,800	52.3	34.2
Little River near Mount Carmel, S. C.	5,200	24.0	17.6	--	--	--
Little River near Washington, Ga.	6,800	23.4	21.7	20,200	69.4	--
Little River near Lincolnton, Ga.	9,290	16.2	19.5	27,600	48.1	--
Savannah River near Clark Hill, S. C.	--	--	--	--	--	--
Stevens Creek near Modoc, S. C.	13,100	24.0	26.6	--	--	--
Savannah River at Augusta, Ga.[2]	104,000	13.9	24.8	310,000	41.3	--
Savannah River at Burtons Ferry Bridge near Millhaven, Ga.[2]	71,200	8.2	22.1	211,000	24.4	--
Brier Creek at Millhaven, Ga.	4,370	6.8	11.1	13,000	20.1	14.8
Savannah River near Clyo, Ga.[2]	68,400	6.9	19.5	202,000	20.5	--

NOTES: [1] Based on regional analyses for the period 1892 to 1949.
[2] Based on records obtained prior to completion of Clark Hill Reservoir.

Minimum discharges at gaging stations in Savannah basin

Gaging station	Period	Minimum monthly discharge						Minimum 7-day discharge						Minimum daily discharge					
		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest	
		C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.
Chattooga River near Clayton, Ga.[1]	1937-55	240	1.16	163	0.787	99	0.478	177	0.855	127	0.614	90	0.435	169	0.816	122	0.589	88	0.425
Panther Creek near Toccoa, Ga.[1,2]	1937-55	31	0.954	16	0.492	15	0.462	25	0.769	13	0.400	12	0.369	24	0.738	12	0.369	10	0.308
Tugaloo River near Hartwell, Ga.[1]	1937-55	1,018	1.12	758	0.834	420	0.462	730	0.803	483	0.531	314	0.345	364	0.400	189	0.208	188	0.207
Do.[3]	1937-55	798	0.878	536	0.590	337	0.371	--	--	--	--	--	--	--	--	--	--	--	--
Keowee River near Newry, S. C.[1]	1937-55	412	0.905	202	0.444	188	0.413	--	--	--	--	--	--	274	0.602	156	0.343	152	0.334
Seneca River near Anderson, S. C.	1937-55	787	0.767	494	0.481	308	0.300	650	0.633	393	0.383	258	0.251	599	0.584	326	0.318	215	0.210
Savannah River near Iva, S. C.[1]	1937-55	2,027	0.909	1,456	0.653	886	0.397	1,700	0.762	1,200	0.538	718	0.322	1,120	0.502	673	0.302	540	0.242
Do.[3]	1937-55	1,816	0.814	1,234	0.553	803	0.360	--	--	--	--	--	--	--	--	--	--	--	--
South Beaverdam Creek near Dewey Rose, Ga.[1]	1937-55	16	0.447	8.0	0.223	2.1	0.0586	12	0.335	5.4	0.151	1.4	0.0391	11	0.307	4.7	0.131	1.0	0.0279
Savannah River near Calhoun Falls, S. C.	1937-55	2,304	0.801	1,655	0.575	978	0.340	1,983	0.690	1,354	0.471	808	0.281	1,320	0.459	845	0.294	636	0.221
Do.[3]	1937-55	2,013	0.700	1,478	0.514	895	0.311	--	--	--	--	--	--	--	--	--	--	--	--
Broad River near Bell, Ga.	1937-55	562	0.738	239	0.314	148	0.194	443	0.581	157	0.206	119	0.156	410	0.538	143	0.188	110	0.144
Little River near Mt. Carmel, S. C.[1]	1937-55	46	0.212	18	0.0829	4.5	0.0207	28	0.129	10	0.0461	1.2	0.0055	24	0.111	9.6	0.0442	1.0	0.0046
Little River near Lincolnton, Ga.[1]	1937-55	46	0.0801	11	0.0192	2.1	0.0037	28	0.0488	3.6	0.0063	1.7	0.0030	21	0.0366	1.8	0.0031	1.7	0.0030
Savannah River near Clarks Hill, S. C.	1940-51	3,707	0.603	2,471	0.402	2,284	0.371	--	--	--	--	--	--	1,880	0.306	1,390	0.226	1,120	0.182
Do.[4]	1937-55	3,217	0.523	1,392	0.226	1,160	0.189	--	--	--	--	--	--	--	--	--	--	--	--
Stevens Creek near Modoc, S. C.[1]	1937-55	14	0.0257	1.0	0.0018	0	0	--	--	--	--	--	--	3.4	0.0062	0	--	0	--
Savannah River at Augusta, Ga.	1937-51	3,701	0.493	2,682	0.357	2,325	0.310	2,859	0.381	2,090	0.278	2,050	0.273	2,350	0.313	1,390	0.185	1,340	0.178
Do.[5]	1952-57	4,509	0.601	4,084	0.544	3,332	0.444	--	--	--	--	--	--	3,880	0.517	3,410	0.454	2,280	0.304
Savannah River at Burtons Ferry near Millhaven, Ga.	1937-51	4,574	0.529	3,573	0.413	2,984	0.345	3,520	0.407	2,571	0.297	2,489	0.288	3,120	0.361	2,240	0.259	2,120	0.245
Do.[5]	1952-57	5,388	0.623	4,590	0.531	4,074	0.471	--	--	--	--	--	--	4,850	0.561	4,770	0.551	3,060	0.354
Brier Creek at Millhaven, Ga.	1937-55	236	0.365	153	0.237	95	0.147	169	0.262	118	0.183	64	0.0991	150	0.232	110	0.170	64	0.0991
Savannah River near Clyo, Ga.	1937-51	5,007	0.508	4,207	0.427	3,431	0.348	4,064	0.413	3,127	0.317	2,997	0.304	3,690	0.375	2,860	0.290	2,830	0.287
Do.[5]	1952-57	5,873	0.596	5,824	0.591	4,500	0.457	--	--	--	--	--	--	5,445	0.553	5,310	0.539	3,610	0.366

NOTES: [1] Record not complete for entire period; minimum-flow data taken from estimates by Thomson, Herrick, and Brown (1956) or from correlative estimates based on records for nearby stations.
[2] Adjusted for diversion by city of Toccoa, Ga.
[3] Adjusted for change in contents of Burton and Mathis Reservoirs.
[4] Adjusted for change in contents of Clark Hill Reservoir; record not completed for entire period; minimum flow data 1937-39 taken from correlative estimate based on records for nearby stations.
[5] Flow regulated by Clark Hill Reservoir since 1952; discharge not adjusted for change in contents of reservoir.

(continued)

TABLE 3.1—Continued

Basin 2 — **Average and extreme discharges at gaging stations in Ogeechee basin**

Gaging station	Drainage area (sq. mi.)	Gage datum (ft. above m.s.l.)	Period of record (water years)	Average discharge			Minimum daily discharge			Period of known floods (water years)	Maximum stage and discharge		
				C.f.s.	Inch	Number of years	C.f.s.	Stage (ft.)	Date		Date	Stage (ft.)	Discharge (c.f.s.)
Ogeechee River near Louisville, Ga.	800	199.24	1937-49	868	14.73	12	86	2.2	Jun., 1945	1840-1961	10/ /29	21.3	46,000
Ogeechee River at Scarboro, Ga.	1,940	111.81	1937-58	1,588	11.11	21	120	0.9	Sep., 1954	1840-1961	10/ /29	17	*
Do.										1937-61	8/17/40	12.8	24,600
Ogeechee River near Eden, Ga.	2,650	19.64	1937-58	2,100	10.76	21	131	0	Sep., 1954	1840-1961	10/ /29	20	*
Do.										1936-61	4/ /36	15.2	30,000
Canoochee River near Claxton, Ga.	555	80.5	1937-58	412	10.08	21	0.86	1.2	Sep., Oct., 1954	1938-61	4/ 2/48	13.9	12,100

* Not determined.

Flood characteristics of streams at gaging stations in Ogeechee basin

Gaging station	Mean annual flood*			Flood of 50-year recurrence interval*		
	Discharge		Stage (ft.)	Discharge		Stage (ft.)
	C.f.s.	C.f.s.m.		C.f.s.	C.f.s.m.	
Ogeechee River near Louisville, Ga.	11,000	13.8	15.8	32,800	41.0	..
Ogeechee River at Scarboro, Ga.	14,600	7.5	11.0	43,300	22.3	..
Ogeechee River near Eden, Ga.	15,200	5.7	12.3	44,800	16.9	..
Canoochee River near Claxton, Ga.	5,620	10.1	13.2	16,600	29.9	..

* Based on regional analysis for the period 1892 to 1949.

Minimum discharges at gaging stations in Ogeechee basin

Gaging station	Period	Minimum monthly discharge						Minimum 7-day discharge						Minimum daily discharge					
		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest	
		C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.
Ogeechee River near Louisville, Ga.*	1937-55	190	0.238	120	0.150	66	0.0825	126	0.158	90	0.112	56	0.0700	114	0.142	86	0.108	55	0.0688
Ogeechee River at Scarboro, Ga.	1937-55	384	0.198	267	0.138	143	0.0737	296	0.153	186	0.0959	121	0.0624	250	0.129	154	0.0794	120	0.0619
Ogeechee River near Eden, Ga.	1937-55	476	0.180	357	0.135	191	0.0721	362	0.137	264	0.0996	138	0.0521	352	0.133	230	0.0868	131	0.0494
Canoochee River near Claxton, Ga.	1937-55	12.6	0.0227	3.8	0.0068	1.2	0.0022	4.5	0.0081	1.5	0.0027	0.86	0.0015	3.3	0.0059	1.3	0.0023	0.86	0.0015

* Record not completed for entire period; minimum flow data taken from estimates by Thomson, Herrick and Brown (1956).

Basin 3 — **Average and extreme discharge at gaging stations in Altamaha basin**

Gaging station	Drainage area (sq. mi.)	Gage datum (ft. above m.s.l.)	Period of record (water years)	Average discharge			Minimum daily discharge			Period of known floods (water years)	Maximum stage and discharge		
				C.f.s.	Inch	Number of years	C.f.s.	Stage (ft.)	Date		Date	Stage (ft.)	Discharge (c.f.s.)
South River near McDonough, Ga.[1]	456	564.99	1939-58	559	16.64	19	54	2.1	Oct., 1954	1940-61	1/ 7/46	24.7	34,500
Do.										1940-61	2/25/61	25.4	29,500
Wildcat Creek near Lawrenceville, Ga.	1.59	970	1953-58	1.25	10.67	5	0.01	0.7	Sep., Oct., 1954	1954-61	5/ 6/56	8.2	806
Pew Creek near Lawrenceville, Ga.	2.23	930	1953-58	2.43	14.80	5	16	0.2	Sep., Oct., 1954	1954-61	7/15/56	7.0	615
Shetley Creek near Norcross, Ga.	0.98	890	1953-58	.957	13.26	5	0.01	0.5	Sep., 1954	1954-61	2/21/61	[14]10.4	2,320
Yellow River near Snellville, Ga.	134	810	1942-58	160	16.21	16	1.6	0.4	Oct., 1954	1943-61	11/29/48	19.4	9,500
Garner Creek near Snellville, Ga.	5.54	830	1953-58	5.61	13.75	5	0.57	0.4	Oct., 1954	1954-61	2/25/61	4.3	1,630
Yellow River near Covington, Ga.[2]	378	616.99	1898, 1899-1901, 1944-58	436	15.65	14	10	0.5	Oct., 1954	1936-61	4/ 7/36	29.9	[15]
Do.										1945-61	11/29/48	20.3	16,200
Alcovy River below Covington, Ga.	244	600	1928-31, 1944-49	381	21.19	8	43	0.7	Sep., 1931	1897-1961	8/30/1887	27.2	12,400
Ocmulgee River near Jackson, Ga.	1,420	419.29	1906-10	2,065	19.74	4				1906-61	12/11/19	26.8	69,000
Do.[3]	1,420	419.29	1910-15, [4]1939-58	1,661	15.88	24	[6]18	2.8	Nov., 1910				
Towaliga River near Forsyth, Ga.[7]	315	410	1929-31, 1944-49	413	17.80	7	33	...	Sep., 1945	1929-61	3/15/29	[15]	15,900
Do.										1945-61	11/27/48	20.9	13,200
Ocmulgee River at Macon, Ga.[3]	2,240	269.80	1893-1911, 1928-58	2,633	15.95	48	128	2.0	Oct., 1954	1893-1961	11/29/48	28.0	83,500
Tobesofkee Creek near Macon, Ga.	182	309.98	1937-58	187	13.94	21	2.5	2.1	Oct., 1954	1938-61	3/21/44	23.2	9,830
Echeconnee Creek near Macon, Ga.	147		1937-43	134	12.38	6	4.0	0.2	Oct., 1938	1937-43 1951-61	5/ 1/53	15.0	15,000
Big Indian Creek at Perry, Ga.	108	279.39	1943-58	78.4	9.85	15	15	0.1	Sep., 1956	1944-61	3/23 and 4/23/44	8.6	3,000

(continued)

TABLE 3.1—Continued

Gaging station	Drainage area (sq. mi.)	Gage datum (ft. above m.s.l.)	Period of record (water years)	Average discharge C.f.s.	Average discharge Inch	Average discharge Number of years	Minimum daily discharge C.f.s.	Minimum daily discharge Stage (ft.)	Minimum daily discharge Date	Period of known floods (water years)	Maximum stage and discharge Date	Maximum stage and discharge Stage (ft.)	Maximum stage and discharge Discharge (c.f.s.)
Ocmulgee River at Hawkinsville, Ga.[3]	3,800	189.56	1944-58	3,892	13.90	14	280	--	Oct., 1931	1841-1961	1/21/25	36.5	79,000
Ocmulgee River at Lumber City, Ga.[3]	5,180	87.48	1936-58	5,319	13.94	22	808	-.9	Oct., Nov., 1954	1841-1961	1/21/25	[16]26.3	98,400
Little Ocmulgee River at Towns, Ga.	329	108.06	1937-46	265	10.93	9	2.2	2.0	Jun., 1941	1925-61	1/ /25	20.4	[15]
Do.										1937-46	12/27/41	16.0	7,480
Oconee River at Athens, Ga.	283	580	1928-31, 1944-49	438	21.01	8	42	--	Sep., 1947	1929-61	3/ 5/29	23.0	9,000
Allen Creek at Talmo, Ga.	17.3	784.42	1951-58	19.9	15.61	7	2.0	0.6	Sep., 1954	1952-61	2/21/61	12.6	3,320
Middle Oconee River near Athens, Ga.[2]	398	555.66	1901-02, 1929-31, 1937-58	469	16.00	24	26	0.4	Sep., 1947	[15]	2/28/02	25.5	19,600
Do.										1938-61	11/30/48	19.6	14,200
Oconee River near Greensboro, Ga.[9]	1,090	409.82	1903-32, 1936-58	1,422	17.71	51	59	-.1	Oct., 1954	1904-61	8/26/08	35.4	66,800
Apalachee River near Bostwick, Ga.[10]	176	565	1944-49	279	21.51	5	38	1.4	Oct., 1947	1945-49	1/ 6/46	8.9	8,500
Apalachee River near Buckhead, Ga.[2]	436	424.07	1901-08, 1937-58	563	17.52	28	16	0.3	Oct., 1954	[15]	8/25/08	[11]27.5	28,900
Do.										1938-61	11/29/48	26.8	23,800
Murder Creek near Monticello, Ga.	24	498.21	1951-58	24.7	13.97	7	0.81	0.2	Sept., Oct., 1954	1952-61	6/ 2/59	7.6	2,510
Oconee River at Milledgeville, Ga.	2,950	230.84	1903-52	3,442	15.84	49	90	--	Aug., Sep., 1925	1886-1952	.. /1886	46.7	[15]
Do.[12]	2,950	230.84	1953-58	[13]2,403	11.05	6	90	--	Apr., 1955	1952-61	2/25/61	42.9	122,000
Oconee River at Dublin, Ga.[12]	4,400	149.08	1897-1958	5,070	15.64	61	350	0.5	Sep., 1951	1894-1961	4/12/36	33.0	96,700
Rocky Creek near Dudley, Ga.	62.9	262	1951-58	56.2	12.12	6	0.37	0.8	Oct., 1954	1952-61	4/ 5/60	10.0	2,930
Oconee River near Mt. Vernon, Ga.[12]	5,110	103.39	1937-55	4,977	13.22	18	470	1.1	Oct., 1954	1930-61	4/ /36	25.5	[15]
Do.										1938-61	12/ 5/48	22.6	66,300
Ohoopee River near Reidsville, Ga.	1,110	73.8	1903-07, 1937-58	908	11.10	25	19	0.7	Sep., 1954	1904-61	1/ /25	28.4	47,000
Altamaha River at Doctortown, Ga.	13,600	28.48	1931-58	12,620	12.60	27	1,430	-3.6	Oct., Nov., 1954	1800-1961	1/23/25	14.6	300,000

NOTES: [1] Figures of discharge include flow diverted from Chattahoochee River (averaging about 12 c.f.s. in 1950 and 45 c.f.s. in 1958) for municipal supply of Atlanta and DeKalb County.
[2] Some regulation and diurnal fluctuation caused by small powerplant above station.
[3] Flow regulation by Lloyd Shoals Reservoir since November 1910 (usable capacity, 77,000 acre-ft).
[4] Figures of discharge unadjusted for change in contents of Lloyd Shoals Reservoir.
[5] Maximum discharge for period 1906-15, 1939-58.
[6] Minimum daily discharge caused by closure of Lloyd Shoals Dam.
[7] Flow regulated by High Falls Reservoir (pondage) since 1905; figures of discharge unadjusted for change in contents.
[8] Maximum known daily discharge, 15,900 c.f.s. March 15, 1929, determined by Corps of Engineers.
[9] Some regulation and diurnal fluctuation at low flow by mills and by Barnett-Shoals powerplant since 1911.
[10] Diurnal fluctuation by small powerplant at High Shoals.
[11] At present site, datum unknown.
[12] Flow regulated by Sinclair Reservoir since November 1952 (usable capacity, 214,000 acre-ft).
[13] Average flow, 1953-58, unadjusted for change in contents of Sinclair Reservoir, adjusted figure is 2,466 c.f.s.
[14] Affected by failure of dam.
[15] Not determined.
[16] Maximum stage occurred at different time than did maximum discharge.

Flood characteristics of streams at gaging stations in Altamaha basin

Gaging station	Mean annual flood* Discharge C.f.s.	Mean annual flood* Discharge C.f.s.m.	Mean annual flood* Stage (ft.)	Flood of 50-year recurrence interval* Discharge C.f.s.	Flood of 50-year recurrence interval* Discharge C.f.s.m.	Flood of 50-year recurrence interval* Stage (ft.)
South River near McDonough, Ga.	15,100	33.1	19.7	40,800	89.5	--
Yellow River near Snellville, Ga.	3,280	24.5	11.3	8,860	66.1	18.9
Yellow River near Covington, Ga.	7,820	20.7	16.1	21,100	55.8	--
Alcovy River below Covington, Ga.	4,420	18.1	14.8	11,900	48.8	26.5
Ocmulgee River near Jackson, Ga.	29,300	20.6	15.8	79,100	55.7	30
Towaliga River near Forsyth, Ga.	6,660	21.1	15.1	18,000	57.1	--
Ocmulgee River at Macon, Ga.	36,500	16.3	22.4	98,600	44.0	--
Tobesofkee Creek near Macon, Ga.	4,320	23.7	15.8	11,700	64.3	--
Echeconnee Creek near Macon, Ga.	--	--	--			--
Big Indian Creek at Perry, Ga.	1,400	13.0	6.7	3,780	35.0	--
Ocmulgee River at Hawkinsville, Ga.	33,200	8.7	26.1	89,600	23.6	--
Ocmulgee River at Lumber City, Ga.	34,300	6.6	16.8	92,600	17.9	--
Little Ocmulgee River at Towns, Ga.	3,850	11.7	14.4	10,400	31.6	--
Oconee River at Athens, Ga.	5,150	18.2	17.3	13,900	49.1	--
Middle Oconee River near Athens, Ga.	7,000	17.6	12.9	18,900	47.5	--
Oconee River near Greensboro, Ga.	17,200	15.8	21.8	46,400	42.6	31
Apalachee River near Bostwick, Ga.	4,980	28.3	6.6	13,400	76.1	--
Apalachee River near Buckhead, Ga.	12,400	28.4	20.5	33,500	76.8	31
Oconee River at Milledgeville, Ga.	43,500	14.7	29.9	117,000	39.7	--
Oconee River at Dublin, Ga.	42,000	9.5	25.0	113,000	25.7	--
Oconee River near Mt. Vernon, Ga.	39,600	7.7	19.4	107,000	20.9	--
Ohoopee River near Reidsville, Ga.	8,900	8.0	16.9	26,400	23.8	--
Altamaha River at Doctortown, Ga.	76,000	5.6	9.4	226,000	16.6	13.3

* Based on regional analysis for the period 1892 to 1949.

(continued)

TABLE 3.1—Continued

Minimum discharges at gaging stations in Altamaha basin

Gaging station	Period	Minimum monthly discharge						Minimum 7-day discharge						Minimum daily discharge					
		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest	
		C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.
South River near McDonough, Ga.[1]	1937-55	187	0.410	87	0.191	67	0.147	157	0.344	73	0.160	58	0.127	145	0.318	70	0.153	54	0.118
Do.[2]	1937-55	--	--	--	--	--	--	--	--	--	--	29	0.0636	--	--	--	--	26	0.0570
Yellow River near Snellville, Ga.[1]	1937-55	35	0.261	9.4	0.0701	3.9	0.0291	22	0.164	7.8	0.0582	1.9	0.0142	19	0.142	3.5	0.0261	1.6	0.0119
Yellow River near Covington, Ga.[1,3]	1937-55	110	0.291	54	0.143	18	0.0476	85	0.225	25	0.0661	12	0.0317	76	0.201	16	0.0423	10	0.0264
Alcovy River below Covington, Ga.[1]	1937-55	70	0.287	35	0.143	12	0.0492	52	0.213	20	0.0820	7.6	0.0311	48	0.197	16	0.0656	7.0	0.0287
Ocmulgee River near Jackson, Ga.[1]	1937-55	585	0.412	369	0.260	99	0.0697	522	0.367	343	0.242	75	0.0528	465	0.327	308	0.217	69	0.0486
Do.[4]	1937-55	431	0.304	104	0.0732	86	0.0606	--	--	--	--	--	--	--	--	--	--	--	--
Towaliga River near Forsyth, Ga.[1,5]	1937-55	44	0.140	6.1	0.0194	2.1	0.0067	25	0.0794	1.7	0.0054	.50	0.0016	22	0.0698	1.4	0.0044	0.33	0.0010
Ocmulgee River at Macon, Ga.	1937-55	828	0.370	491	0.219	165	0.0737	654	0.292	439	0.196	139	0.0620	610	0.272	330	0.147	128	0.0571
Do.[4]	1937-55	639	0.285	215	0.0960	111	0.0496	--	--	--	--	--	--	--	--	--	--	--	--
Tobesofkee Creek near Macon, Ga.	1937-55	34	0.187	12	0.0659	5.5	0.0302	27	0.148	5.8	0.0319	2.8	0.0154	24	0.132	5.1	0.0280	2.2	0.0121
Echeconnee Creek near Macon, Ga.[1]	1937-55	17	0.116	4.8	0.0326	1.8	0.0122	12	0.0816	1.9	0.0129	.79	0.0054	11	0.0748	1.7	0.0116	0.6	0.0041
Big Indian Creek at Perry, Ga.[1]	1937-55	40	0.370	28	0.259	28	0.259	33	0.306	22	0.204	20	0.185	31	0.287	21	0.194	17	0.157
Ocmulgee River at Hawkinsville, Ga.[1]	1937-55	1,572	0.414	830	0.218	447	0.118	1,080	0.284	760	0.200	420	0.111	1,000	0.263	550	0.145	420	0.111
Do.[4]	1937-55	1,315	0.346	554	0.146	418	0.110	--	--	--	--	--	--	--	--	--	--	--	--
Ocmulgee River at Lumber City, Ga.	1937-55	1,937	0.374	1,436	0.277	887	0.171	1,770	0.342	1,357	0.262	813	0.157	1,700	0.328	1,340	0.259	808	0.156
Do.[4]	1937-55	1,782	0.344	1,160	0.224	858	0.166	--	--	--	--	--	--	--	--	--	--	--	--
Little Ocmulgee River at Towns, Ga.[1]	1937-55	11	0.0334	3.2	0.0097	--	--	4.6	0.0140	2.5	0.0076	0.95	0.0029	3.8	0.0115	2.1	0.0064	0.87	0.0026
Oconee River at Athens, Ga.[1]	1937-55	120	0.424	37	0.131	30	0.106	91	0.322	27	0.0954	22	0.0777	82	0.290	23	0.0813	20	0.0707
Middle Oconee River near Athens, Ga.	1937-55	160	0.402	53	0.133	42	0.106	129	0.324	38	0.0955	32	0.0804	106	0.266	33	0.0829	28	0.0703
Oconee River near Greensboro, Ga.[1]	1937-55	437	0.401	138	0.127	87	0.0798	321	0.294	90	0.0826	65	0.0596	285	0.261	74	0.0679	59	0.0541
Apalachee River near Bostwick, Ga.[1]	1937-55	65	0.369	36	0.205	14	0.0795	51	0.290	23	0.131	10	0.0568	48	0.273	19	0.108	9.4	0.0534
Apalachee River near Buckhead, Ga.	1937-55	137	0.314	72	0.165	26	0.0596	103	0.236	44	0.101	18	0.0413	97	0.222	36	0.0825	16	0.0367
Oconee River at Milledgeville, Ga.	1937-51	881	0.299	438	0.148	401	0.136	663	0.225	295	0.100	251	0.0851	628	0.213	231	0.0783	217	0.0736
Do.[6]	1952-58	651	0.221	507	0.172	344	0.117	347	0.118	225	0.0763	146	0.0495	146	0.0495	92	0.0312	90	0.0305
Oconee River at Dublin, Ga.	1937-51	1,285	0.292	733	0.167	672	0.153	979	0.222	469	0.107	367	0.0834	940	0.214	429	0.0975	350	0.0795
Do.[6]	1952-57	966	0.220	851	0.193	469	0.107	635	0.144	405	0.0920	392	0.0891	582	0.132	368	0.0836	351	0.0798
Oconee River near Mt. Vernon, Ga.	1937-51	1,485	0.291	955	0.187	854	0.167	1,201	0.235	658	0.129	587	0.115	1,140	0.223	628	0.123	568	0.111
Do.[6]	1952-55					605	0.118	--	--	--	--	476	0.0931	--	--	--	--	450	0.0881
Do.[7]	1937-55	1,453	0.284	854	0.167	276	0.0540	--	--	--	--	--	--	--	--	--	--	--	--
Ohoopee River near Reidsville, Ga.	1937-55	91	0.0820	48	0.0432	21	0.0189	50	0.0450	31	0.0279	20	0.0180	45	0.0405	28	0.0252	19	0.0171
Altamaha River at Doctortown, Ga.	1937-55	3,955	0.291	2,778	0.204	1,748	0.129	3,070	0.226	2,340	0.172	1,459	0.107	2,930	0.215	2,250	0.165	1,430	0.105

NOTES: [1] Record not complete for entire period; minimum flow data taken from estimates by Thomson, Herrick and Brown (1956).
[2] Adjusted for diversion from Chattahoochee River.
[3] Some regulation and/or diurnal fluctuation of low flow due to powerplant.
[4] Adjusted for change in contents of Lloyd Shoals Reservoir above station.
[5] Flow regulated by High Falls Dam.
[6] Flow regulated by Sinclair Reservoir since 1952; discharge not adjusted for change in contents of reservoir.
[7] Adjusted for change in contents of Sinclair Reservoir since 1952.

Basin 4 **Average and extreme discharges at gaging stations in Satilla—St. Marys basins**

Gaging station	Drainage area (sq. mi.)	Gage datum (ft. above m.s.l.)	Period of record (water years)	Average discharge			Minimum daily discharge			Period of known floods (water years)	Maximum stage and discharge		
				C.f.s.	Inch	Number of years	C.f.s.	Stage (ft.)	Date		Date	Stage (ft.)	Discharge (c.f.s.)
Satilla Basin													
Satilla River near Waycross, Ga.	1,200	66.43	1937-58	866	9.80	21	6.2	2.5	Nov., 1954	1862-1961	4/ 4/48	22.4	39,000
Hurricane Creek near Alma, Ga.	150	136.44	1952-58	79.1	7.16	7	0	..	At times each year	1952-61	9/29/53	9.4	4,450
Little Satilla River near Offerman, Ga.	646	59.00	1951-58	289	6.07	7	0	..	Oct., Nov., 1954	1951-61	9/29/53	13.5	17,200
Satilla River at Atkinson, Ga.	2,790	14.79	1930-58	1,932	9.51	28	25	1.9	Nov., 1931	1862-1961	9/ /29	27.2	110,000
St. Marys Basin													
North Prong St. Marys River at Moniac, Ga.	160*	89.40	1921-24, 1927-30, 1932-34, 1951-58	133	11.28	13	0	..	At times in most years	1921-34 1950-61	9/19/28	16.7	6,060
South Prong St. Marys River at Glen St. Mary, Fla.	150	77.13	1950-58	93.1	8.43	8	0.8	1.6	May, 1950	1947-61	9/ /47	13.0	6,700
St. Marys River near Macclenny, Fla.	720*	40.00	1927-58	635	11.97	32	12	0.7	May, 1932	1927-61	9/25/47	22.3	28,100

* Part of watershed in Okefenokee Swamp.

(continued)

TABLE 3.1—Continued

Flood characteristics of streams at gaging stations in Satilla–St. Marys basins

Gaging station	Mean annual flood*			Flood of 50-year recurrence interval*		
	Discharge		Stage (ft.)	Discharge		Stage (ft.)
	C.f.s.	C.f.s.m.		C.f.s.	C.f.s.m.	
Satilla Basin						
Satilla River near Waycross, Ga.	8,200	6.83	16.4	31,700	26.4	21.6
Little Satilla River near Offerman, Ga.	5,500	8.51	10.2	21,300	33.0	--
Satilla River at Atkinson, Ga.	16,000	5.73	16.7	61,900	22.2	23.2
St. Marys Basin						
North Prong St. Marys River at Moniac, Ga.	1,700	10.6	13.6	6,320	39.5	--
St. Marys River near Macclenny, Fla.	8,000	11.1	16.4	29,800	41.4	22.5

* Based on regional analysis for the period 1892 to 1949 in Georgia and 1927-53 in Florida.

Minimum discharges at gaging stations in Satilla–St. Marys basins

Gaging station	Period	Minimum monthly discharge						Minimum 7-day discharge						Minimum daily discharge					
		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest	
		C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.
Satilla Basin																			
Satilla River near Waycross, Ga.	1937-55	36	0.0300	15	0.0125	7.5	0.0062	27	0.0225	12	0.0100	6.3	0.0052	22	0.0183	12	0.0100	6.2	0.0052
Satilla River at Atkinson, Ga.	1937-55	122	0.0437	47	0.0168	25	0.0090	88	0.0315	37	0.0133	21	0.0075	80	0.0287	36	0.0129	21	0.0075
St. Marys Basin																			
St. Marys River near Macclenny, Fla.	1937-55	33	0.0458	23	0.0319	21	0.0292	26	0.0361	17	0.0236	17	0.0236	25	0.0347	13	0.0222	16	0.0222

Basin 5

Average and extreme discharges at gaging stations in Suwannee basin

Gaging station	Drainage area (sq. mi.)	Gage datum (ft. above m.s.l.)	Period of record (water years)	Average discharge			Minimum daily discharge			Period of known floods (water years)	Maximum stage and discharge		
				C.f.s.	Inch	Number of years	C.f.s.	Stage (ft.)	Date		Date	Stage (ft.)	Discharge (c.f.s.)
Suwannee River at Fargo, Ga.	[1]1,260	91.90	[2]1921-23, 1927-32, 1937-58	1,018	10.97	25	0	--	At times in 1931,-43,-54	1927-61	10/ 1/28	19.5	13,800
Suwannee River at White Springs, Fla.	1,990	48.54	1906-09, 1927-58	1,660	11.32	33	4.8	1.8	Nov., 1931	1927-61	4/5,6/1948	36.6	28,500
Alapaha River near Alapaha, Ga.	663	209.34	1937-58	477	9.77	22	0		July, Sep. to Nov., 1954	1900-61	4/ /28	18.0	16,000
Alapaha River at Statenville, Ga.	1,400	76.77	1921, 1932-58	908	8.80	27	17	0.8	Nov., 1954	1862-1961	4/ 6/1948	29.8	27,300
Little River near Adel, Ga.	547	171.08	1940-58	473	11.74	18	0.29	1.0	Oct., 1954	1928-61	4/ 2/48	21.0	38,800
Withlacoochee River near Quitman, Ga.	1,480	84.30	1921, 1929-32, 1937-48	1,214	11.13	14	6.8	1.8	Nov., Dec., 1940	1928-61	4/ 4/48	31.7	66,000
Withlacoochee River near Pinetta, Fla.	2,220	47.21	1932-58	1,445	8.84	27	73	6.3	Aug., 1955	1938-61	4/ 5/48	38.6	79,400
Suwannee River at Ellaville, Fla.	6,580	27.22	1927-58	6,071	12.53	31	890	1.7	July, 1955	1862-1961	4/7,8/48	40.9	95,300
Suwannee River at Luraville, Fla.	6,900	16.49	1927-37	7,135	14.04	10	1,290	1.4	June, July, 1935	1862-1955	4/ /48	[4]53.5	[3]
Suwannee River at Branford, Fla.	7,090	4.81	1931-58	6,215	11.90	27	1,530	2.4	July, 1955	1862-1961	4/11/48	34.1	83,900
New River near Lake Butler, Fla.	212	83.80	1950-58	98.5	6.31	8	0.2	0.5	June, 1955	1950-61	9/ 8/50	12.0	6,470
Santa Fe River at Worthington, Fla.	630	42.74	1932-58	404	8.70	26	0.6	6.8	June, 1955	1931-61	6/17/34	24.8	17,500
Do.										1931-61	10/21/44	24.9	15,700
Santa Fe River near High Springs, Fla.	950	26.36	1931-58	734	10.49	27	31	0.4	Apr., May 4, 1956	1931-61	3/14/48	15.7	12,700
Santa Fe River near Ft. White, Fla.	1,080	20.86	1928-30, 1932-58	1,545	19.41	28	617	0.5	May, 1957	1926-61	3/14/48	[3]	12,300
Do.										1926-61	4/12/48	13.7	[3]
Suwannee River near Bell, Fla.	9,260	3.60	1932-56	8,513	12.48	24	2,490	1.0	Jan., 1956	1862-1956	4/13/48	27.4	82,30
Suwannee River near Wilcox, Fla.	9,500	0.00	1931, 1942-58	9,887	14.13	18	8,270	1.6	Feb., 1957	1862-1961	4/14/48	22.3	84,700

NOTES
[1] Part of watershed in Okefenokee Swamp.
[2] Gage heights only.
[3] Not determined.
[4] Elevation above mean sea level.

Flood characteristics of streams at gaging stations in Suwannee basin

Gaging station	Mean annual flood*			Flood of 50-year recurrence interval*		
	Discharge		Stage (ft.)	Discharge		Stage (ft.)
	C.f.s.	C.f.s.m.		C.f.s.	C.f.s.m.	
Suwannee River at Fargo, Ga.	5,000	4.0	13.9	19,400	15.4	--
Suwannee River at White Springs, Fla.	8,600	4.3	26.8	32,000	16.1	--
Alapaha River near Alapaha, Ga.	4,500	6.8	12.7	17,400	26.4	18.3

(continued)

TABLE 3.1—Continued

Gaging station	Mean annual flood*			Flood of 50-year recurrence interval*		
	Discharge		Stage (ft.)	Discharge		Stage (ft.)
	C.f.s.	C.f.s.m.		C.f.s.	C.f.s.m.	
Alapaha River at Statenville, Ga.	6,000	4.3	22.4	23,200	16.6	29.3
Little River near Adel, Ga.	6,000	11.0	16.6	23,200	42.6	19.5
Withlacoochee River near Quitman, Ga.	9,600	6.5	20.7	37,200	25.3	28.4
Withlacoochee River near Pinetta, Fla.	9,000	4.1	20.8	33,500	15.1	35.3
Suwannee River at Ellaville, Fla.	18,500	2.8	18.5	68,800	10.5	36.3
Suwannee River at Branford, Fla.	16,700	2.4	19.5	62,100	8.8	32.1
Santa Fe River at Worthington, Fla.	7,000	11.1	20.8	26,000	41.3	--
Santa Fe River near High Springs, Fla.	4,400	4.6	8.5	16,400	17.3	--
Santa Fe River near Ft. White, Fla.	4,900	4.5	5.7	18,200	16.9	[2]
Suwannee River near Bell, Fla.	20,500	2.2	14.5	76,300	8.2	26.3

NOTES: [1] Based on regional analysis for the period 1892 to 1949 in Georgia and 1927-53 in Florida.
[2] Affected by backwater from Suwannee River.

Minimum discharges at gaging stations in Suwannee basin

Gaging station	Period	Minimum monthly discharge						Minimum 7-day discharge						Minimum daily discharge					
		Median annual		*Second lowest annual*		*Lowest*		*Median annual*		*Second lowest annual*		*Lowest*		*Median annual*		*Second lowest annual*		*Lowest*	
		C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.
Suwannee River at Fargo, Ga.	1937-55	39	0.0310	1.2	0.0010	0.12	0.0001	21	0.0167	0	0	0	0	18	0.0143	0	0	0	0
Suwannee River at White Springs, Fla.	1937-55	72	0.0362	13	0.0065	12	0.0060	47	0.0236	10	0.0050	8.7	0.0044	44	0.0221	8.7	0.0044	7.5	0.0038
Alapaha River near Alapaha, Ga.	1937-55	7.3	0.0110	0.61	0.0009	0	0	1.3	0.0020	0.20	0.0003	0	0	0.8	0.0012	0.10	0.0002	0	0
Alapaha River at Statenville, Ga.	1937-55	75	0.0536	34	0.0243	21	0.0150	58	0.0414	23	0.0164	18	0.0128	53	0.0378	22	0.0157	17	0.0121
Little River near Adel, Ga.*	1937-55	8.6	0.0157	0.98	0.0018	0.60	0.0011	--	--	--	--	--	--	--	--	--	--	0.24	0.0004
Withlacoochee River near Quitman, Ga.	1937-55	25	0.0169	7.1	0.0048	5.5	0.0037	14	0.0094	5.3	0.0036	5.3	0.0036	13	0.0088	5.3	0.0036	4.7	0.0032
Withlacoochee River near Pinetta, Fla.	1937-55	155	0.0698	88	0.0396	78	0.0351	131	0.0590	77	0.0347	77	0.0347	125	0.0563	77	0.0347	73	0.0329
Suwannee River at Ellaville, Fla.	1937-55	--	--	--	--	--	--	1,486	0.226	957	0.145	893	0.136	1,420	0.216	946	0.144	890	0.135

* Record not complete for entire period; minimum flow data taken from estimates by Thomson, Herrick and Brown (1956).

Basin 6 Average and extreme discharges at gaging stations in Ochlockonee basin and nearby coastal area

Gaging station	Drainage area (sq. mi.)	Gage datum (ft. above m.s.l.)	Period of record (water years)	Average discharge			Minimum daily discharge			Period of known floods (water years)	Maximum stage and discharge		
				C.f.s.	Inch	Number of years	C.f.s.	Stage (ft.)	Date		Date	Stage (ft.)	Discharge (c.f.s.)
Steinhatchee Basin													
Steinhatchee River near Cross City, Fla.	360	7.84	1950-58	254	9.58	8	3.6	2.4	6/27,28/50	1950-61	10/ 4/57	15.8	4,320
Fenholloway Basin													
Fenholloway River at Foley, Fla.	80	29.36	1947-58	[1]	--	--	6.3	6.6	10/15/50	1946-61	3/10/48	16.0	2,640
Econfina Basin													
Econfina River near Perry, Fla.	230	14.35	1950-58	121	7.14	8	2.4	1.9	7/ 8/55	1950-61	9/17/57	12.8	2,540
Aucilla Basin													
Aucilla River at Lamont, Fla.	680	42.90	1950-58	222	4.43	8	0	--	At times in 1955, 1957	1950-61	9/18/57	14.9	6,580
Ochlockonee Basin													
Ochlockonee River near Thomasville, Ga.	550	133.6	1937-58	449	11.08	21	2.6	0.7	10/17/38	1937-61	4/ 2/48	29.1	72,000
Tired Creek near Cairo, Ga.	60	159.0	1943-58	61.3	13.87	15	0.1	0	6/10/55	1943-61	4/ 1/48	16.3	28,100
Ochlockonee River near Havana, Fla.	1,020	59.16	1926-58	934	12.43	32	17	10.8	10/23-28, 11/1/54	1928-61	4/ 4/48	35.1	55,900
Little River near Quincy, Fla.	250	83.19	1950-58	196	10.64	8	8.1	1.0	6/ 8/56	1950-61	9/27/60	20.4	23,200
Ochlockonee River near Bloxham, Fla.	1,660	24.69	1926-54, 1955-58	1,614	13.20	28	[3]1.2	3.6	11/ 1/57	1862-1956	4/ 5/48	23.5	50,200
Do.										1862-1961	9/30/57	[4]	[5]55,000
Telogia Creek near Bristol, Fla.	130	99.50	1950-58	165	17.23	8	28	1.4	9/14, 10/26/54	1950-61	4/ 3/60	[4]	4,640
Do.										1950-61	3/ 7/59	9.4	4,300

NOTES: [1] Since February 1, 1954, natural flow of stream affected by return of large amount of ground water pumped by cellulose plant upstream.
[2] Maximum daily; caused by failure of Jackson Bluff dam.
[3] *Caused by closure of dam (indeterminate prior to October 1954)*
[4] Not determined.
[5] Maximum daily discharge (estimated on basis of change in contents in Lake Talquin); caused by failure of earth embankment of Jackson Bluff Dam 3,000 ft. upstream.

(continued)

TABLE 3.1—Continued

Flood characteristics of streams at gaging stations in Ochlockonee basin and nearby coastal area

Gaging station	Mean annual flood*			Flood of 50-year recurrence interval*		
	Discharge		Stage (ft.)	Discharge		Stage (ft.)
	C.f.s.	C.f.s.m.		C.f.s.	C.f.s.m.	
Fenholloway Basin						
Fenholloway River at Foley, Fla.	950	5.3	14.5	3,530	19.6	..
Ochlockonee Basin						
Ochlockonee River near Thomasville, Ga.	5,800	10.5	16.0	22,400	40.7	21.6
Tired Creek near Cairo, Ga.	3,800	63.3	8.7	14,700	24.5	13.8
Ochlockonee River near Havana, Fla.	7,000	6.9	27.0	26,000	25.5	32.4

* Based on regional analyses for the period 1892 to 1949 in Georgia and 1927-53 in Florida.

Minimum discharges at gaging stations in Ochlockonee basin

Gaging station	Period	Minimum monthly discharge						Minimum 7-day discharge						Minimum daily discharge					
		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest	
		C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.
Ochlockonee River near Thomasville, Ga.	1937-55	24	0.0436	5.7	0.0104	4.7	0.0085	7.7	0.0140	4.0	0.0073	3.9	0.0071	7.3	0.0133	3.5	0.0064	2.6	0.0047
Tired Creek near Cairo, Ga.*	1937-55	10	0.167	2.9	0.0483	1.3	0.0217	5.1	0.0850	1.3	0.0217	0.3	0.0050	4.1	0.0683	1.1	0.0183	0.1	0.0017
Ochlockonee River near Havana, Fla.	1937-55	112	0.110	39	0.0382	22	0.0216	64	0.0627	33	0.0324	17	0.0167	60	0.0588	29	0.0284	17	0.0167

* Record not complete for entire period; minimum flow data taken by Thomson, Herrick and Brown (1956).

Basin 7 **Average and extreme discharges at gaging stations in Apalachicola basin**

Gaging station	Drainage area (sq. mi.)	Gage datum (ft. above m.s.l.)	Period of record (water years)	Average discharge			Minimum daily discharge			Period of known floods (water years)	Maximum stage and discharge		
				C.f.s.	Inches	Number of years	C.f.s.	Stage (ft.)	Date		Date	Stage (ft.)	Discharge (c.f.s.)
Chattahoochee River near Leaf, Ga.[1]	150	1,219.47	1907-08, 1940-58	378	34.21	19	72	1.3	Oct., 1941	19[illegible]0-61	1/ 7/46	13.6	14,100
Soque River near Demorest, Ga.[1]	156	1,152.16	1904-09, 1929-32 1940-52	355	30.89	17	18	0.9	Oct., 1931	1870-1961	6/16/49	28.5	21,000
Chattahoochee River near Gainesville, Ga.	559	974.98	1901-04, 1937-56	1,240	30.13	20	208	1.2 0.9	Oct., 1954 Oct., 1931	1937-55	1/ 7/46	26.2	45,800
Chestatee River near Dahlonega, Ga.[1]	153	1,128.6	1929-32, 1940-58	333	29.59	20	49	2.4	Oct., 1941	1907-61	8/12/07	[2]25	[21]
Do.										1929-32, 1940-61	1/ 7/46	22.1	15,300
Chattahoochee River near Buford, Ga.	1,060	905.20	1901-02, 1942-55	2,128	27.28	14	364	3.3	Sep., 1951	1921-55	1/ 8/46	32.6	55,000
Do.[3]	1,060	905.20	1956-58	[4]874	11.19	3	262	2.7	May 1958	1956-61	2/13/58	15.7	11,100
Chattahoochee River near Norcross, Ga.[3]	1,170	878.14	1903-46, 1957-58	[4]2,233	25.93	46	132	0.5	Aug., 1925	1896-1961	1/ 8/46	27.7	55,000
Chattahoochee River near Roswell, Ga.[3 5]	1,230	849.50	1942-58	[4]2,088	23.08	17	315	1.2	Aug., 1957	1921-61	1/ 8/46	23.4	56,000
Chattahoochee River at Atlanta, Ga.[3 6]	1,450	750.10	1928-32, 1937-58	[4]2,401	22.48	25	296	1.7	Sep., 1957	1896-1961	12/19	29	64,000
Chattahoochee River at Oakdale, Ga.	1,600	738.4	1896-1904	3,416	29.05	8	675	-.5	Oct., 1897	1921-61	1/ 8/46	29.4	[21]
Do.										1896-1910	12/30/01	27.0	[7]48,800
Sweetwater Creek near Austell, Ga.	246	857.01	1904-06, 1913 1937-58	293	16.15	22	2.1	-.7	Oct., 1954	1916-61	7/ 8/16	20.0	12,600
Chattahoochee River near Whitesburg, Ga.	2,430	684.[illegible]6	1939-54	3,740	20.90	15	468	1.0	Oct., 1941	1921-61	1/10/46	[8]25.1	59,000
Yellowjacket Creek near LaGrange, Ga.	182	601	1951-58	204	15.20	7	5.2	0.7	Oct., 1954	1951-61	2/25/61	22.5	21,600
Chattahoochee River at West Point, Ga.[3]	3,550	551.67	1896-1958	5,532	21.15	62	224	1.6	Sep., 1925	1827-1961	12/10/19	30.0	134,000
Mountain Creek near Hamilton, Ga.	61.7	550	1944-58	81.1	17.78	15	4.0	1.4	Sep., 1956	1944-61	7/11/48	[9]16.6	11,800
Chattahoochee River at Columbus, Ga.[10]	4,670	185.14	1929-58	[11]6,307	18.32	29	480	0.5	Oct., 1931	1827-1961	3/15/29	[25]53.2	198,000
Upatoi Creek at Fort Benning, Ga.	447	189.66	1943-48	668	20.23	5	115	5.4	Oct., 1943	1943-48	3/22/43	[12]21.3	[21]
Uchee Creek near Fort Mitchell, Ala.	325	201.76	1954-58	346	14.39	5	6.4	0.8	Sep., 1956	1946-61	3/ 8/58	22.0	21,100
Barbour Creek near Eufaula, Ala.[14]	93.3	143.07	1954-58	70.3	10.22	5	.6	-.2	Aug., 1956	1954-58	9/25/56	20.2	6,250
Chattahoochee River at Columbia, Ala.[10]	8,040	72.23	1928-58	[11]10,520	17.78	30	1,210	2.5	Oct., 1954	1827-1961	3/18/29	56.0	203,000
Chattahoochee River at Alaga, Ala.[10]	8,340	62.72	1938-45	[11]10,316	16.83	6	1,420	1.1	Oct., Nov.,1941	1827-1961	3/18/29	46.0	207,000
Flint River near Griffin, Ga.[1 15]	272	711.44	1937-58	317	15.88	21	2.5	1.2	Oct., 1954	1929-61	3/14/29	17.9	15,300
Flint River near Molena, Ga.	990	646.78	1946-52	1,355	18.60	7	51	5.0	Sep., 1951	1939-53	11/27/48	25.9	31,100
Flint River near Woodbury, Ga.[1]	1,090	649	1900-20	1,510	18.87	20	86	-.4	Oct., 1911	1900-27	12/11/19	17.1	38,400
Potato Creek near Thomaston, Ga.[16]	186	600	1938-58	218	15.88	21	.78	2.1	Oct., 1954	1938-61	11/27/48	8.8	9,240
Flint River near Culloden, Ga.	1,850	334.54	1911-23, 1928-32 1937-58	2,345	17.24	35	95	1.0	Oct., 1931	1913-61	3/15/29	38.4	92,000
Whitewater Creek near Butler, Ga.	80	365.85	1944-51	156	26.47	8	98	1.7	June 1945	1944-51	3/23/44	6.5	1,340
Whitewater Creek below Rambulett Creek near Butler, Ga.	93.4	365.85	1952-58	161	23.55	7	103	0.9	Sep., 1956	1952-61	5/ 4/57	7.0	2,160
Flint River at Montezuma, Ga.	2,900	255.83	1905-13, 1930-58	3,444	16.15	36	585	0.5	Oct., 1941 Sep., 1956	1897-1961	3/ 2/1897	26	97,000
Do.											3/17/29	27.4	92,000
Flint River at Oakfield, Ga.[17]	3,860	193.29	1930-58	4,357	15.34	28	152		June 1941	1898-1961	1/20/25	35.1	90,000
Kinchafoonee Creek at Preston, Ga.	197	337.7	1952-58	180	12.40	7	20	1.3	Sep., 1956	1900-61	1/43	11.4	[21]
Do.										1952-61	5/ 4/53	8.8	6,000
Flint River at Albany, Ga.[18]	5,310	150.03	1902-21, 1930-58	6,226	15.88	48	327	1.4	Aug., 1930	1893-1961	1/21/25	37.8	92,000
Flint River at Newton, Ga.[18]	5,740	110.20	1938-50, 1957-58	7,126	16.83	14	840	3.0	Oct., 1940	1893-1961	1/21/25	41.3	94,000
Ichawaynochaway Creek near Milford, Ga.[19]	620	150.3	1905-08, 1940-58	785	17.24	21	120	0.8	Sep., 1954 Periods	1916-61	7/16	17.2	15,500

(continued)

TABLE 3.1—Continued

Gaging station	Drainage area (sq. mi.)	Gage datum (ft. above m.s.l.)	Period of record (water years)	Average discharge: C.f.s.	Average discharge: Inches	Average discharge: Number of years	Minimum daily discharge: C.f.s.	Minimum daily discharge: Stage (ft.)	Minimum daily discharge: Date	Period of known floods (water years)	Maximum stage and discharge: Date	Maximum stage and discharge: Stage (ft.)	Maximum stage and discharge: Discharge (c.f.s.)
Alligator Creek near Milford, Ga.[20]	14	167.16	1942-52	11.2	10.86	9	0	..	most years	1942-52	3/7/44	4.4	[21]
Chickasawatchee Creek at Elmodel, Ga.	320	..	1940-50	379	16.02	10	5.2	0.8	Oct., Nov., 1943	1940-61	3/10 and 4/4/48	11.9	3,630
Ichawaynochaway Creek near Newton, Ga.	1,020	113.8	1921, 1937-47	1,187	15.74	10	205	0.5	June, Sep., 1941	1916-61	7/16	35.0	26,000
Big Cypress Creek near Milford, Ga.	[22]	210.56	1942-50	3.26	..	7	0	..	Many days each year	1942-50	4/1/48	2.8	105
Flint River at Bainbridge, Ga.[18]	7,570	58.06	1908-14, 1929-58	8,661	15.47	36	1,900	0.2	Dec., 1955	1893-1961	1/24/25	40.9	101,000
Long Branch near Damascus, Ga.	18	220	1945-50	22.9	17.24	4	0	..	Many days each year	1945-50	4/1/48	4.6	787
Spring Creek near Iron City, Ga.	485	85.7	1921, 1937-58	473	13.23	21	9.1	1.0	Oct., Nov., 1954	1938-61	4/2/48	19.9	12,600
Apalachicola River at Chattahoochee, Fla.	17,100	45.58	1929-54	[24]22,050	17.51	26	5,010	-2.2	Oct., Nov., 1954	1929-61	3/20/29	34.7	293,000
Do.[23]			1955-58	15,482	12.28	4							
Chipola River near Altha, Fla.	781	19.95	1913-14, 1922-27, 1929-31, 1943-58	1,501	26.09	23	356	8.4	Nov., 1955	1922-61	9/20/26	33.6	25,000

NOTES:

1 Diurnal fluctuation at low flow caused by mill dam above station.
2 Affected by failure of dam.
3 Flow regulated by Lake Sidney Lanier (Buford Reservoir) since January 1956 (usable capacity, 1,686,000 acre-feet).
4 Flow for 1956-58 unadjusted for change in contents of Lake Sidney Lanier (Buford Reservoir).
5 Diversion for municipal supply by DeKalb County about 6 miles upstream from station; monthly diversion equivalent to 33 c.f.s. in 1958.
6 Considerable diurnal fluctuation caused by Morgan Falls hydro-electric plant 9½ miles from station.
7 Maximum daily discharge.
8 *At site one mile upstream, same datum.*
9 At site 300 ft. upstream, datum 3.00 ft. lower.
10 Flow regulated by Lake Sidney Lanier (Buford Reservoir) since 1956 and Bartletts Ferry Dam (Lake Harding, usable capacity, 136,000 acre-feet) since 1926.
11 Average flow, 1929-58, unadjusted for change in content of reservoir.
12 Backwater from Chattahoochee River.
13 From information by local resident.
14 Diurnal fluctuation at low flow caused by diversion of an average of 1.5 c.f.s. for municipal supply for city of Eufaula.
15 Diversion for municipal supply for city of Griffin; average monthly diversion equivalent to 2½ c.f.s. in 1958.
16 Some regulation at low flow caused by diversion for municipal and industrial supplies at Thomaston, Ga.
17 Flow regulated by powerplant at Warwick Reservoir (Crisp County) since 1930 (capacity, about 35,000 acre-feet); normal operation of powerplant does not materially affect figures of monthly runoff.
18 Flow regulated by powerplant and Flint River Reservoir since 1921 (capacity, 7,500 acre-feet) and Warwick Reservoir; normal operation of powerplants does not materially affect figures of monthly runoff.
19 Moderate diurnal fluctuations at low flows.
20 Flow largely derived from springs; diurnal fluctuation of low flow caused by water losses.
21 Not determined.
22 Drainage area includes Cypress Swamp, the area of which is indeterminate.
23 Flow regulated by Jim Woodruff Reservoir since 1954 (usable capacity, 37,000 acre-feet) and by Lake Sidney Lanier (Buford Reservoir) and Bartletts Ferry Dam.
24 Average flow, 1929-54 and 1955-58, unadjusted for change in contents of reservoir.
25 Maximum stage occurred at different time than did maximum discharge.

Flood characteristics of streams at gaging stations in Apalachicola basin

Gaging station	Mean annual flood[1]: Discharge C.f.s.	Mean annual flood[1]: Discharge C.f.s.m.	Mean annual flood[1]: Stage (ft.)	Flood of 50-year recurrence interval[1]: Discharge C.f.s.	Flood of 50-year recurrence interval[1]: Discharge C.f.s.m.	Flood of 50-year recurrence interval[1]: Stage (ft.)
Chattahoochee River near Leaf, Ga.	8,000	53.3	9.7	21,600	144	17.0
Soque River near Demorest, Ga.	6,900	44.2	13.5	18,600	119	26.6
Chattahoochee River near Gainesville, Ga.	22,500	40.3	19.2	60,800	109	--
Chestatee River near Dahlonega, Ga.	7,990	52.2	15.3	21,600	141	--
Chattahoochee River near Buford, Ga.	21,700	20.5	22.7	58,600	55.3	35
Chattahoochee River near Norcross, Ga.	19,200	16.4	16.7	51,800	44.3	26.8
Chattahoochee River near Roswell, Ga.	20,100	16.3	15.0	43,400	35.3	21.3
Chattahoochee River at Atlanta, Ga.	22,400	15.4	17.1	48,400	33.4	25.6
Chattahoochee River at Oakdale, Ga.	23,100	14.4	19.0	49,900	31.2	27.0
Sweetwater Creek near Austell, Ga.	4,160	16.9	12.2	11,200	45.4	--
Chattahoochee River near Whitesburg, Ga.	28,200	11.6	16.7	60,900	25.1	--
Yellowjacket Creek near LaGrange, Ga.	4,630	25.4	11.7	12,500	68.7	--
Chattahoochee River at West Point, Ga.	48,000	13.5	19.8	104,000	29.3	26.3
Mountain Creek near Hamilton, Ga.	3,840	62.2	7.7	10,000	169	15.2
Chattahoochee River at Columbus, Ga.	66,800	14.3	33.2	144,000	30.8	48.9
Upatoi Creek at Fort Benning, Ga.	9,500	21.3	16.7	25,600	57.3	--
Uchee Creek near Fort Mitchell, Ala.	10,200	31.4	13.3	33,100	102	--
Barbour Creek near Eufaula, Ala.	2,800	30.0	11.9	9,100	97.5	--
Chattahoochee River at Columbia, Ala.	78,500	9.8	41.3	170,000	21.1	--
Chattahoochee River at Alaga, Ala.	77,500	9.3	--	167,000	20.0	--
Flint River near Griffin, Ga.	6,300	23.2	13.8	17,000	62.5	--
Flint River near Molena, Ga.	18,200	18.4	20.0	49,100	49.6	--
Flint River near Woodbury, Ga.	20,000	18.3	10.9	54,000	49.5	--
Potato Creek near Thomaston, Ga.	3,960	24.3	6.5	10,700	57.5	--
Flint River near Culloden, Ga.	32,200	17.4	25.8	86,900	47.0	37.2
Whitewater Creek near Butler, Ga.	409	5.1	4.1	1,100	13.8	6.1

(continued)

TABLE 3.1—Continued

Gaging station	Mean annual flood*			Flood of 50-year recurrence interval*		
	Discharge		Stage (ft.)	Discharge		Stage (ft.)
	C.f.s.	C.f.s.m.		C.f.s.	C.f.s.m.	
Flint River at Montezuma, Ga.	32,700	11.3	20.1	88,300	30.4	27.1
Flint River at Oakfield, Ga.	31,300	8.1	22.2	84,500	21.9	--
Flint River at Albany, Ga.	37,000	7.0	24.9	99,900	18.8	--
Flint River at Newton, Ga.	35,400	6.2	24.2	95,600	16.7	--
Ichawaynochaway Creek at Milford, Ga.	6,640	10.7	10.8	17,900	28.9	--
Chickasawhatchee Creek at Elmodel, Ga.	2,200	6.9	9.7	5,940	18.6	--
Ichawaynochaway Creek near Newton, Ga.	7,770	7.6	14.7	21,000	20.6	--
Flint River at Bainbridge, Ga.[2]	36,300	4.8	--	98,000	12.9	--
Spring Creek near Iron City, Ga.	5,700	11.8	16.3	15,400	31.7	21
Apalachicola River at Chattahoochee, Fla.	90,000	5.3	--	333,000	19.5	--

NOTES: [1] Based on regional analysis for the period 1929-51 in Alabama, 1927-53 in Florida, and 1892 to 1949 in Georgia.
[2] Affected by backwater from Jim Woodruff Reservoir.

Minimum discharges at gaging stations in Apalachicola basin

Gaging station	Period	Minimum monthly discharge						Minimum 7-day discharge						Minimum daily discharge					
		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest	
		C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.
Chattahoochee River near Leaf, Ga.[1]	1937-55	142	0.947	86	0.573	84	0.560	123	0.820	81	0.540	76	0.507	118	0.787	78	0.520	72	0.480
Soque River near Demorest, Ga.[1]	1937-55	150	0.962	85	0.545	78	0.500	120	0.769	79	0.506	74	0.474	94	0.603	37	0.237	[2]26	0.167
Chattahoochee River near Gainesville, Ga.	1937-55	533	0.953	280	0.501	276	0.494	450	0.805	264	0.472	254	0.454	394	0.705	242	0.433	208	0.372
Chestatee River near Dahlonega, Ga.[1]	1937-55	122	0.797	69	0.451	66	0.431	101	0.660	61	0.399	55	0.359	97	0.635	60	0.392	49	0.320
Chattahoochee River near Buford, Ga.[1]	1937-55	794	0.749	449	0.424	420	0.396	702	0.662	415	0.392	380	0.358	661	0.624	364	0.344	360	0.340
Chattahoochee River near Norcross, Ga.[1]	1937-55	845	0.722	446	0.381	410	0.350	784	0.670	397	0.339	370	0.316	678	0.579	382	0.326	320	0.274
Chattahoochee River near Roswell, Ga.[1]	1937-55	850	0.691	441	0.359	421	0.342	708	0.576	401	0.326	383	0.311	676	0.550	389	0.316	328	0.267
Do.[3]	1937-55	--	--	--	--	449	0.365	--	--	--	--	412	0.335	--	--	--	--	356	0.289
Chattahoochee River at Atlanta, Ga.	1937-55	972	0.670	493	0.340	432	0.298	752	0.519	441	0.304	392	0.270	714	0.492	422	0.291	340	0.234
Do.[3]	1937-55	--	--	--	--	460	0.317	--	--	--	--	421	0.290	--	--	--	--	368	0.254
Sweetwater Creek near Austell, Ga.	1937-55	66	0.268	16	0.0650	4.4	0.0179	47	0.191	13	0.0528	2.3	0.0093	40	0.163	12	0.0488	2.1	0.0085
Chattahoochee River near Whitesburg, Ga.[1]	1937-55	1,320	0.543	564	0.232	490	0.202	956	0.393	498	0.205	440	0.181	920	0.379	468	0.192	370	0.152
Yellowjacket Creek near LaGrange, Ga.[1]	1937-55	46	0.253	14	0.0769	10	0.0549	27	0.148	11	0.0604	5.8	0.0319	23	0.126	8.8	0.0484	5.2	0.0286
Chattahoochee River at West Point, Ga.	1937-55	1,737	0.489	651	0.183	510	0.144	1,236	0.348	569	0.160	432	0.122	1,200	0.338	532	0.150	364	0.103
Mountain Creek near Hamilton, Ga.[1]	1937-55	20	0.324	8.3	0.135	6.6	0.107	17	0.276	6.6	0.107	5.7	0.0924	16	0.259	6.3	0.102	5.5	0.0891
Chattahoochee River at Columbus, Ga.	1937-55	2,203	0.472	938	0.201	701	0.150	1,811	0.388	872	0.187	640	0.137	1,340	0.287	840	0.180	600	0.128
Do.[4]	1937-55	2,138	0.458	587	0.125	551	0.118	--	--	--	--	--	--	--	--	--	--	--	--
Upatoi Creek at Fort Benning, Ga.[1]	1937-55	190	0.425	68	0.152	36	0.0805	129	0.289	37	0.0828	20	0.0447	115	0.257	33	0.0738	17	0.0380
Uchee Creek near Fort Mitchell, Ga.	1953-58	15	0.0452	10	0.0311	9.6	0.0295	12	0.0363	9.2	0.0283	7.7	0.0237	6.4	0.0197	6.4	0.0197	6.4	0.0197
Barbour Creek near Eufaula, Ala.	1953-58	7.7	0.0826	5.2	0.0562	4.5	0.0484	3.6	0.0386	2.9	0.0311	1.4	0.0150	2.3	0.0247	1.7	0.0182	.6	0.0064
Chattahoochee River at Columbia, Ala.	1937-55	3,604	0.448	1,943	0.242	1,371	0.171	3,166	0.394	1,657	0.206	1,297	0.161	2,930	0.364	1,630	0.203	1,210	0.150
Do.[4]	1937-55	3,445	0.428	1,617	0.201	1,210	0.150	--	--	--	--	--	--	--	--	--	--	--	--
Chattahoochee River at Alaga, Ala.[1]	1937-55	3,750	0.450	2,000	0.240	1,400	0.168	3,300	0.396	1,700	0.204	1,300	0.156	3,000	0.360	1,420	0.170	1,200	0.144
Do.[4]	1937-55	3,533	0.424	1,615	0.194	1,213	0.145	--	--	--	--	--	--	--	--	--	--	--	--
Flint River near Griffin, Ga.	1937-55	69	0.254	22	0.0809	6.0	0.0221	40	0.147	16	0.0588	3.2	0.0118	35	0.129	13	0.0478	2.5	0.0092
Do.[5]	1937-55	72	0.265	24	0.0882	10	0.0367	--	--	--	--	7.0	0.0257	--	--	--	--	6.5	0.0239
Flint River near Molena, Ga.[1]	1937-55	266	0.269	68	0.0687	42	0.0424	150	0.152	46	0.0465	38	0.0384	130	0.131	38	0.0384	37	0.0374
Potato Creek near Thomaston, Ga.[1]	1937-55	38	0.204	14	0.0753	2.6	0.0140	24	0.129	4.1	0.0220	1.8	0.0097	18	0.0968	2.8	0.0151	0.78	0.0042
Flint River near Culloden, Ga.	1937-55	583	0.315	166	0.0897	108	0.0584	337	0.182	117	0.0632	99	0.0535	308	0.166	98	0.0530	97	0.0524
Whitewater Creek near Butler, Ga.[1]	1937-55	120	1.500	100	1.250	96	1.200	110	1.375	96	1.200	91	1.138	110	1.375	92	1.150	90	1.125
Flint River at Montezuma, Ga.	1937-55	1,341	0.462	804	0.277	639	0.220	1,087	0.375	665	0.229	618	0.213	1,010	0.348	600	0.207	585	0.202
Flint River at Oakfield, Ga.[6]	1937-55	1,604	0.416	864	0.224	858	0.222	1,324	0.343	[illegible]	0.207	741	0.192	360	0.0933	165	0.0427	152	0.0394
Flint River at Albany, Ga.[7]	1937-55	2,044	0.385	1,341	0.253	1,175	0.221	1,741	0.328	1,076	0.203	845	0.159	865	0.163	598	0.113	462	0.0870

(continued)

TABLE 3.1—Continued

Gaging station	Period	Minimum monthly discharge: Median annual C.f.s.	Median annual C.f.s.m.	Second lowest annual C.f.s.	Second lowest annual C.f.s.m.	Lowest C.f.s.	Lowest C.f.s.m.	Minimum 7-day discharge: Median annual C.f.s.	Median annual C.f.s.m.	Second lowest annual C.f.s.	Second lowest annual C.f.s.m.	Lowest C.f.s.	Lowest C.f.s.m.	Minimum daily discharge: Median annual C.f.s.	Median annual C.f.s.m.	Second lowest annual C.f.s.	Second lowest annual C.f.s.m.	Lowest C.f.s.	Lowest C.f.s.m.
Flint River at Newton, Ga.[1 7]	1937-55	2,650	0.462	1,900	0.331	1,700	0.296	2,297	0.400	1,600	0.279	1,400	0.244	1,600	0.279	1,100	0.192	840	0.146
Ichawaynochaway Creek at Milford, Ga.[1]	1937-55	300	0.484	180	0.290	145	0.234	244	0.394	137	0.221	129	0.208	222	0.358	123	0.198	120	0.194
Chickasawatchee Creek at Elmodel, Ga.[1]	1937-55	23	0.0719	3.0	0.0094	1.2	0.0038	18	0.0562	2.0	0.0062	0.94	0.0029	17	0.0531	1.8	0.0056	.91	0.0028
Ichawaynochaway Creek near Newton, Ga.[1]	1937-55	391	0.383	170	0.167	120	0.118	326	0.320	150	0.147	110	0.108	315	0.309	140	0.137	110	0.108
Flint River at Bainbridge, Ga.[7]	1937-55	3,704	0.489	2,465	0.326	2,217	0.293	3,447	0.455	2,200	0.291	2,150	0.284	3,280	0.433	1,930	0.255	1,900	0.251
Spring Creek near Iron City, Ga.	1937-55	74	0.152	20	0.0482	11	0.0227	63	0.130	15	0.0309	9.3	0.0192	57	0.118	14	0.0289	9.1	0.0188
Apalachicola River at Chattahoochee, Ga.	1937-55	9,127	0.534	5,499	0.322	5,319	0.311	8,887	0.520	5,333	0.312	5,161	0.302	8,600	0.503	5,160	0.302	5,010	0.293
Do.[8]	1937-55	9,127	0.534	5,521	0.323	5,342	0.312	--	--	--	--	--	--	--	--	--	--	--	--

NOTES: [1] Record not complete for entire period; minimum flow data taken from estimates by Thomson, Herrick, and Brown (1956).
[2] Adjusted figure, based on change-in-contents data for Habersham Mills Reservoir.
[3] Adjusted for diversion for DeKalb County municipal supply.
[4] Adjusted for change-in-contents of Bartletts Ferry Reservoir.
[5] Adjusted for diversion for munic[illegible]al supply of Griffin, Ga.
[6] Minimum daily discharge affected by regulation at Warwick Dam.
[7] Minimum daily discharge affected by regulation at Albany, Dam.
[8] Adjusted for change-in-contents of Jim Woodruff Reservoir.

Basin 8

Average and extreme discharges at gaging stations in Choctawhatchee and Escambia basins and nearby coastal area

Gaging station	Drainage area (sq. mi.)	Gage datum (ft. above m.s.l.)	Period of record (water years)	Average discharge: C.f.s.	Inches	No. of years	Minimum daily discharge: C.f.s.	Stage (ft.)	Date	Period of known floods (water years)	Maximum stage and discharge: Date	Stage (ft.)	Discharge (c.f.s.)
Bear Creek Basin													
Econfina Creek near Bennett, Fla.	182	1.03	1936-58	528	39.38	23	307	4.1	Jan., 1956	[1]	9/26 or 4/28	15.0	[1]
Do.										1936-61	4/2/48	12.5	4,860
Choctawhatchee River Basin													
West Fork Choctawhatchee River at Blue Springs, Ala.	84.7	289.24	1944-53	143	22.93	10	12	1.30	July 1951	1944-52	3/29/44	9.1	4,820
Do.										[1]	9/26/56	11.5	[1]
East Fork Choctawhatchee River near Midland City, Ala.	297	179.1	1952-58	307	14.05	6	26	2.45	Sep., Oct., 1954	1952-61	5/4/53	23.8	15,700
Choctawhatchee River near Newton, Ala.	683	138.56	1922-27, 1935-58	968	19.25	27	61	1.51	Sep., 1954	[1]	3/15/29	42	[1]
Do.										1922-27 1930-61	1/17/25	28.0	28,000
Pea River near Ariton, Ala.	492	246.72	1939-58	638	17.62	20	9.2	1.63	Oct., 1954	[1]	3/29	25	[1]
Do.										1939-61	4/4/60	20.4	22,000
Pea River (at Pera) near Samson, Ala.	1,187	97.95	1904-13, 1922-25, 1935-58	1,718	19.66	33	63	0.58	Oct., 1935	[1]	3/15/29	45.3	[1]
Do.										1904-13, 1922-25, 1936-61	1/20/25	42.0	30,000
Choctawhatchee River at Caryville, Fla.	3,499	39.02	1929-58	5,284	20.50	29	752	0.1	Sep., 1957	1928-61	3/17/29	27.1	206,000
Holmes Creek at Vernon, Fla.	386	10.70	1950-58	524	18.43	8	234	10.3	July 1955	1950-61	4/4/60	23.4	10,900
Choctawhatchee River near Bruce, Fla.	4,384	3.94	1931-58	6,943	21.50	28	1,480	-.2	Oct., 1954	1929-61	3/29	[2]25.0	220,000
Alaqua Creek Basin													
Alaqua Creek near DeFuniak Springs, Fla.	65.6	19.65	1951-58	135	27.93	7	27	6.0	un., July, 1955	1951-61	9/26/53	18.5	5,160
Yellow River Basin													
Lightwood Knot Creek at Babbie, Ala.	113	...	1944-53	227	27.29	8	18	0.13	July 1950, Aug., 1951	1944-53	9/11/44	11.9	12,100
Yellow River at Milligan, Fla.	624	45.00	1938-58	1,132	24.63	20	143	1.1	Oct., 1954	[1]	3/29	26.2	[1]
Do.										1938-61	12/6/53	15.1	28,000
Shoal River near Mossy Head, Fla.	123	105.59	1951-58	187	20.64	7	44	3.6	June 1956	1951-61	9/27/53	21.9	8,690
Shoal River near Crestview, Fla.	474	47.21	1938-58	1,034	29.61	20	263	1.0	May 1955	[1]	3/29	[3]64.2	[1]
Do.										1938-61	7/7/40	14.3	21,700
Yellow River near Holt, Fla.	1,220	17.95	1934-41	2,228	24.79	8	812	0.8	Oct., 1934	[1]	3/29	[3]43.4	[1]
Do.										1933-41	7/9/40	15.6	35,100
Blackwater Basin													
Blackwater River near Baker, Fla.	205	60.50	1950-58	245	16.22	8	61	2.8	Sep., 1954	1950-61	12/4/53	20.8	17,200
Big Coldwater Creek near Milton, Fla.	237	9.10	1939-58	518	29.67	20	158	1.9	June 1956	1938-61	8/17/39	17.3	23,100
Escambia Basin													
Conecuh River near Troy, Ala.	253	313.30	1944-53	355	19.06	10	0.8	0.36	Aug., 1951	1944-53	11/28/48	16.1	18,000
Conecuh River at Brantley, Ala.	492	226.2	1938-58	690	19.04	21	23	0.87	Sep., 1954	[1]	3/29	26	[1]
Do.										1938-61	11/29/48	23.0	15,800
Patsaliga Creek at Luverne, Ala.	294	267.53	1944-58	367	20.02	15	5	0.96	Oct., 1954	1944-58	11/28/48	16.8	16,700
Conecuh River near Andalusia, Ala.	1,344	106.77	1904-20, 1930-52	973	19.94	38	47	0.11	Oct., Nov., 1941	1905-52	3/15/29	47.6	154,000
Sepula River near McKenzie, Ala.	464	155.96	1938-58	623	18.24	21	3.5	2.30	Sep., 1954	[1]	3/29	33	[1]
Do.										1938-61	3/17/38	24.5	28,100
Pigeon Creek near Thad, Ala.	296	172.58	1938-58	425	19.51	21	7.8	1.88	Aug., 1956	[1]	3/29	30	[1]
Do.										1938-61	11/29/48	27.1	17,100
Conecuh River near Brooklyn, Ala.	2,460	76.95	1935-57	3,688	20.36	22	152	1.61	Sep., 1954	[1]	3/15/29	47	[1]
Do.										1936-57	12/1/48	38.6	67,300
Murder Creek near Evergreen, Ala.	170	178.29	1938-58	265	21.18	21	39	2.77	Sep., 1954	[1]	3/29	26.6	[1]
Do.										1938-61	2/25/61	16.1	22,000
Big Escambia Creek at Flomaton, Ala.	323	52.40	1939-51	665	27.97	12	159	0.41	Oct., 195[illegible]	[1]	3/29	25.9	[1]
Do.										1938-51	9/27/39	19.3	41,400
Escambia River near Century, Fla.	3,817	28.34	1935-58	6,008	21.37	24	609	1.3	Sep., Oct., 1954	1929-61	3/29	37.8	315,000
Pine Barren Creek near Barth, Fla.	75.3	29.86	1953-58	123	22.17	6	52	3.2	June 1956	1952-61	4/14/55	18.0	24,800
Perdido Basin													
Perdido River at Barrineau Park, Fla.	394	25.77	1941-58	752	25.91	17	209	1.3	Sep., 1954	[1]	3/15/29	25.7	[1]
Do.										1941-61	4/15/55	23.9	39,000
Styx River near Loxley, Ala.	93.2	...	1952-58	149	21.72	7	16	0.68	June 1955	[1]	9/26	22.2	[1]
Do.										1952-61	12/6/53	19.7	14,000

NOTES: [1] Not determined.
[2] At former site 1 mile downstream, datum, 0.25 ft lower.
[3] Elevation above mean sea level.

(continued)

TABLE 3.1—Continued

Flood characteristics of streams at gaging stations in Choctawhatchee and Escambia basins and nearby coastal area

Gaging station	Mean annual flood[1]			Flood of 50-year recurrence interval[1]		
	Discharge		Stage (ft.)	Discharge		Stage (ft.)
	C.f.s.	C.f.s.m.		C.f.s.	C.f.s.m.	
Bear Creek Basin						
Econfina Creek near Bennett, Fla.	1,800	9.9	9.9	6,700	36.8	--
Choctawhatchee River Basin						
West Fork Choctawhatchee River at Blue Springs, Ala.	2,100	24.8	6.9	6,800	80.3	10
East Fork Choctawhatchee River near Midland City, Ala.	5,000	16.8	17.0	16,300	54.9	24
Choctawhatchee River near Newton, Ala.	9,600	14.1	19.9	31,200	45.7	38
Pea River near Ariton, Ala.	8,500	17.3	16.8	27,600	56.1	21
Pea River (at Pera) near Samson, Ala.	13,300	11.2	27.8	43,200	35.4	41
Choctawhatchee River at Caryville, Fla.	33,000	9.4	13.5	123,000	35.2	21.2
Choctawhatchee River near Bruce, Fla.	38,000	8.7	12.7	141,000	32.2	21.9
Yellow Basin						
Lightwood Knot Creek at Babbie, Ala.	4,200	37.2	8.1	13,700	121	12
Yellow River at Milligan, Fla.	9,700	15.6	10.8	36,100	57.9	--
Shoal River near Crestview, Fla.	8,500	17.9	9.8	31,600	66.7	--
Blackwater Basin						
Big Coldwater Creek near Milton, Fla.	5,800	24.5	9.6	21,600	91.1	--
Escambia Basin						
Conecuh River near Troy, Ala.	9,000	35.6	13.5	29,200	115	18
Conecuh River at Brantley, Ala.	8,800	17.9	19.2	28,600	58.1	28
Patsaliga Creek at Luverne, Ala.	7,400	29.7	14.2	24,000	96.4	--
Conecuh River near Andalusia, Ala.	17,500	13.0	31.1	57,000	42.4	42
Sepulga River near McKenzie, Ala.	11,700	25.2	18.0	38,000	81.9	27
Pigeon Creek near Thad, Ala.	7,600	25.7	22.3	24,700	83.4	30
Conecuh River near Brooklyn, Ala.	31,500	12.8	32.0	100,000	40.7	40
Murder Creek near Evergreen, Ala.	4,300	25.3	11.7	14,000	82.4	15
Big Escambia Creek at Flomaton, Ala.	8,000	24.8	11.3	30,000	92.9	18
Escambia River near Century, Fla.	42,000	11.0	18.4	156,000	40.9	--
Perdido Basin						
Perdido River at Barrineau Park, Fla.	7,500	19.0	14.4	27,900	70.6	21.7
Styx River near Loxley, Ala.	2,400	25.8	9.8	12,000	129	19

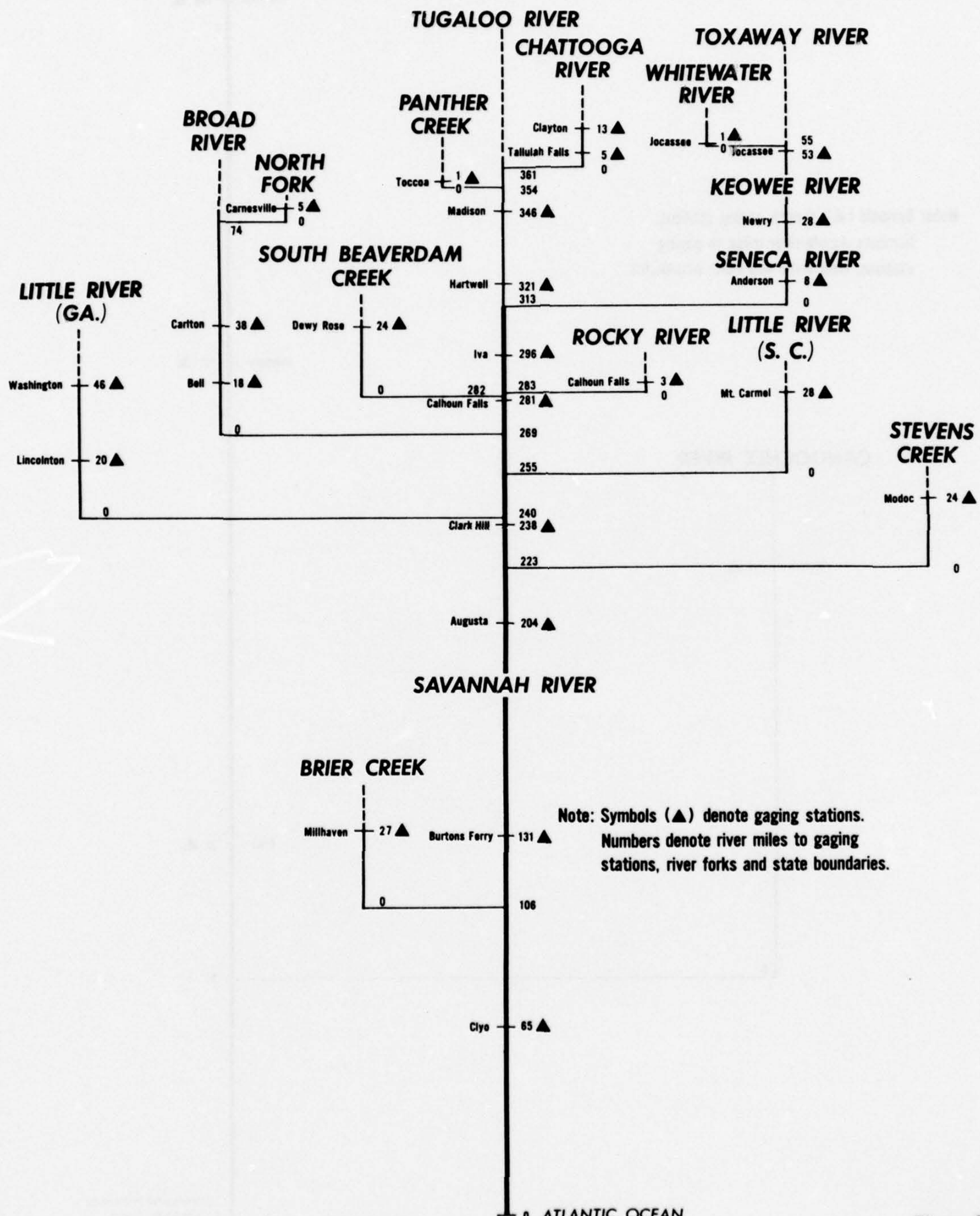
* Based on regional analysis for the period 1929-51 in Alabama and 1927-53 in Florida.

Minimum discharges at gaging stations in Choctawhatchee and Escambia basins and nearby coastal area

Gaging station	Period	Minimum monthly discharge						Minimum 7-day discharge						Minimum daily discharge					
		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest		Median annual		Second lowest annual		Lowest	
		C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.	C.f.s.	C.f.s.m.
Choctawhatchee Basin																			
West Fork Choctawhatchee River at Blue Springs, Ala.	1943-53	46.4	0.548	32.3	0.381	26.4	0.312	35.7	0.421	19.6	0.231	14	0.165	28	0.331	17	0.201	12	0.142
East Fork Choctawhatchee River near Midland City, Ala.	1952-56	54.8	0.185	43.6	0.147	40.2	0.135	47.8	0.161	43.3	0.146	28.1	0.0946	28	0.0943	27	0.0909	26	0.0875
Choctawhatchee River near Newton, Ala.	1922-27 1935-56	22.8	0.334	112	0.164	95.1	0.139	163	0.239	85.6	0.125	68.4	0.100	132	0.193	71	0.104	61	0.0893
Pea River near Ariton, Ala.	1938-56	56.6	0.115	21.2	0.0431	13.6	0.0276	46.4	0.0943	15.1	0.0307	10.3	0.0209	32	0.0650	10	0.0203	9.2	0.0187
Pea River (at Pera) near Samson, Ala.	1904-12 1922-25 1935-56	328	0.276	131	0.110	108	0.0910	255	0.215	119	0.100	93.1	0.0784	192	0.162	74	0.0623	63	0.0531
Yellow Basin																			
Lightwood Knot Creek at Babbie, Ala.	1944-52	82.1	0.727	43.2	0.382	38.4	0.340	51.6	0.457	20.4	0.181	18.6	0.165	34	0.301	25	0.221	18	0.159
Escambia Basin																			
Conecuh River near Troy, Ala.	1944-53	18	0.0711	6.62	0.0262	6.37	0.0252	7.8	0.0306	2.4	0.0095	1.2	0.0047	5.1	0.0202	2.1	0.0083	.8	0.0032
Conecuh River at Brantley, Ala.	1937-56	104	0.211	43.5	0.0834	27.6	0.0561	80.7	0.164	43.4	0.0682	24.3	0.0494	73	0.148	26	0.0528	23	0.0467
Patsaliga River at Luverne, Ala.	1943-56	43	0.173	10.8	0.0434	6.62	0.0266	27.4	0.110	10.4	0.0418	5.7	0.0229	18	0.0723	5.6	0.0225	5.0	0.0201
Conecuh River near Andalusia, Ala.	1904-19 1929-52	354	0.263	210	0.156	189	0.141	272	0.202	132	0.0982	126	0.0937	167	0.124	56	0.0417	47	0.0350
Sepulga River near McKenzie, Ala.	1937-56	39.8	0.0858	6.66	0.0144	4.71	0.0102	24.7	0.0532	11.5	0.0248	3.99	0.0086	22	0.0474	4.7	0.0101	3.5	0.0075
Pigeon Creek near Thad, Ala.	1937-56	60.1	0.203	18.2	0.0615	13.4	0.0453	45.6	0.154	28.9	0.0976	12.1	0.0409	35	0.118	9	0.0304	7.8	0.0264
Conecuh River near Brooklyn, Ala.	1935-56	569	0.231	217	0.0882	209	0.0850	422	0.196	241	0.0980	171	0.0695	303	0.123	158	0.0642	152	0.0618
Murder Creek near Evergreen, Ala.	1937-56	93.5	0.550	50.3	0.296	46.7	0.275	83	0.488	51.4	0.302	39.7	0.234	73	0.429	43	0.253	39	0.229
Big Escambia Creek near Flomaton, Ala.	1939-51	268	0.830	220	0.681	208	0.644	242	0.749	164	0.508	159	0.492	216	0.669	175	0.542	170	0.526
Perdido Basin																			
Styx River near Loxley, Ala.	1951-56	26.9	0.289	25.8	0.277	24.2	0.260	26	0.279	20	0.215	17.1	0.183	20	0.215	19	0.204	16	0.172

UNITED STATES GEOLOGICAL SURVEY GAGING STATIONS

SAVANNAH BASIN



Note: Symbols (▲) denote gaging stations. Numbers denote river miles to gaging stations, river forks and state boundaries.

Figure 3.3

UNITED STATES GEOLOGICAL SURVEY GAGING STATIONS

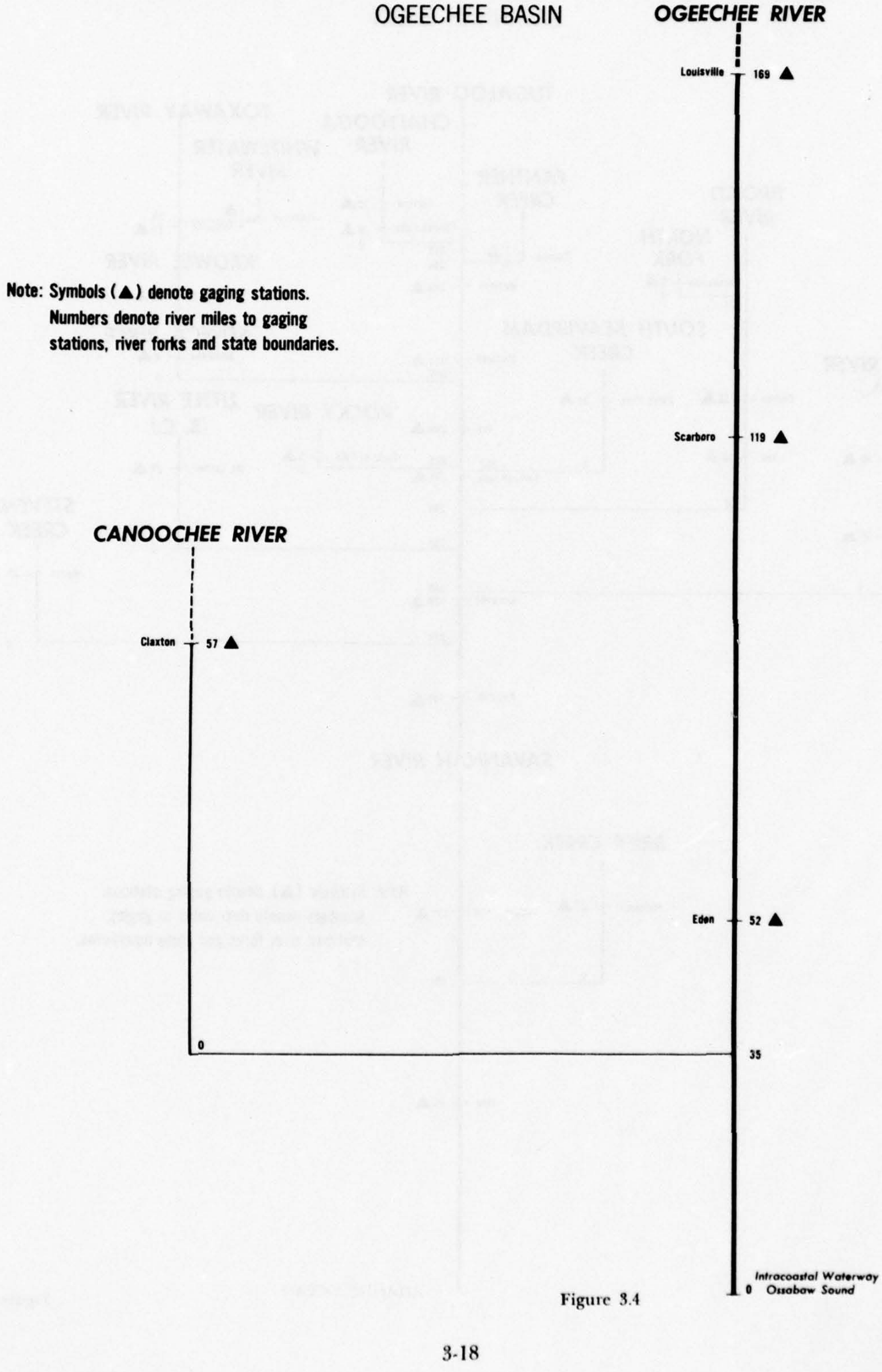
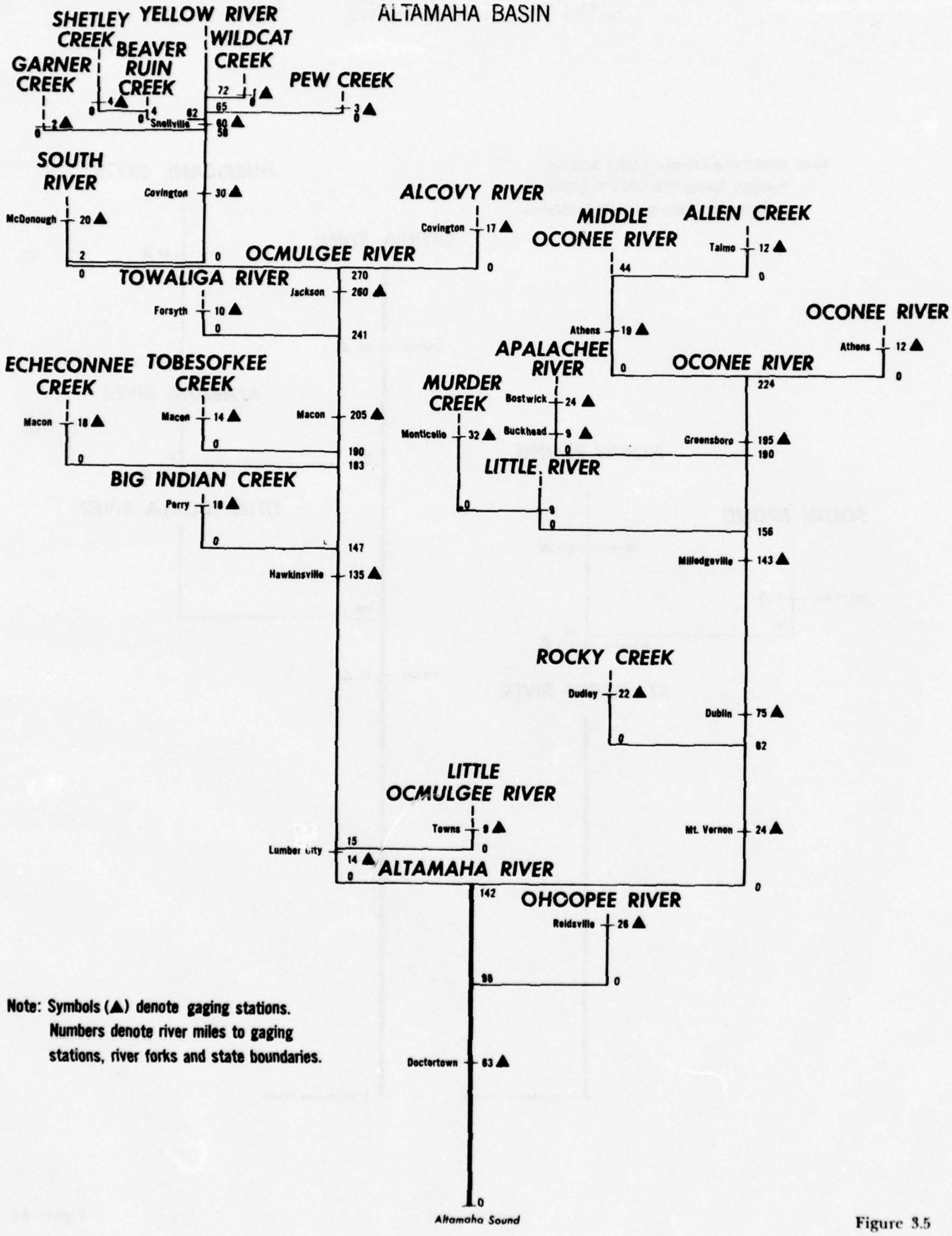


Figure 3.4

UNITED STATES GEOLOGICAL SURVEY GAGING STATIONS

ALTAMAHA BASIN



Note: Symbols (▲) denote gaging stations.
Numbers denote river miles to gaging stations, river forks and state boundaries.

Figure 3.5

UNITED STATES GEOLOGICAL SURVEY GAGING STATIONS

SATILLA-ST. MARYS BASINS

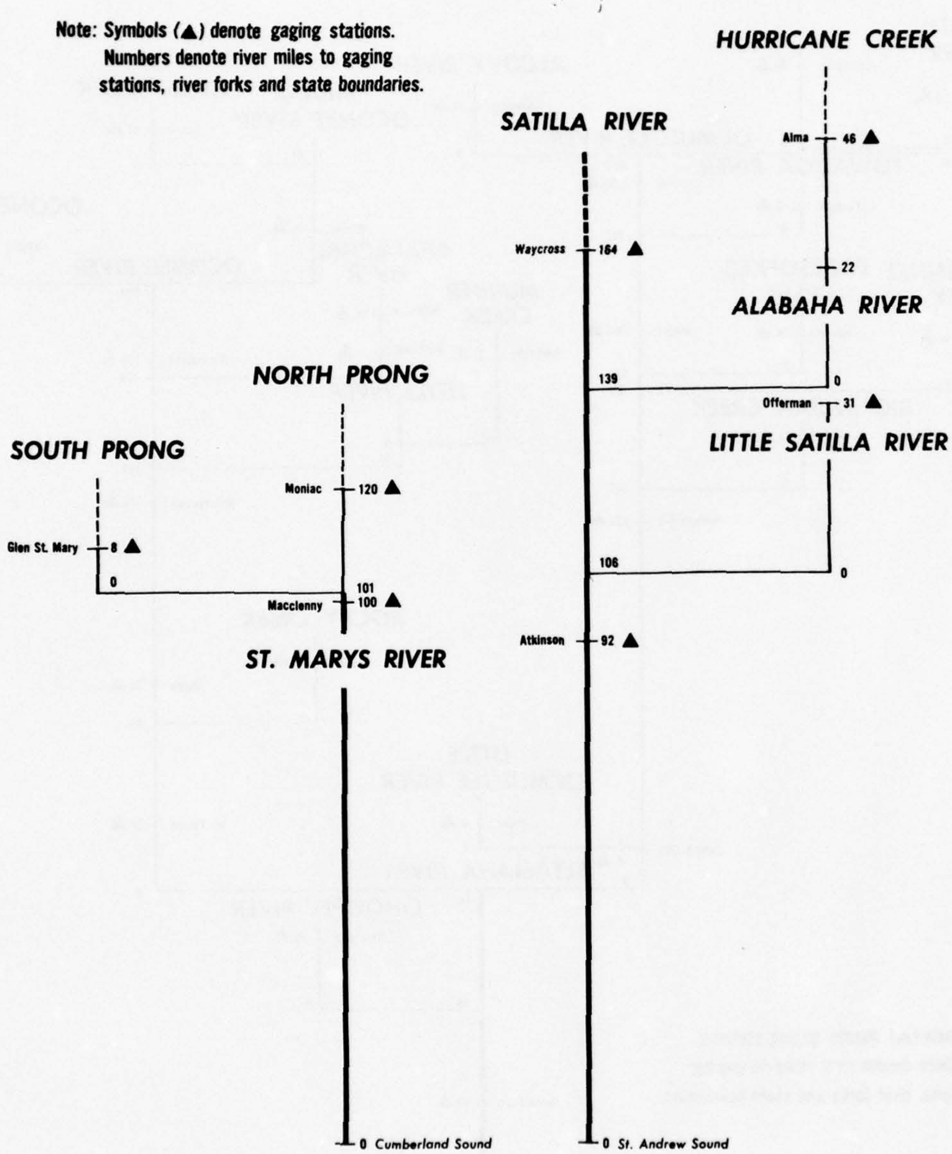
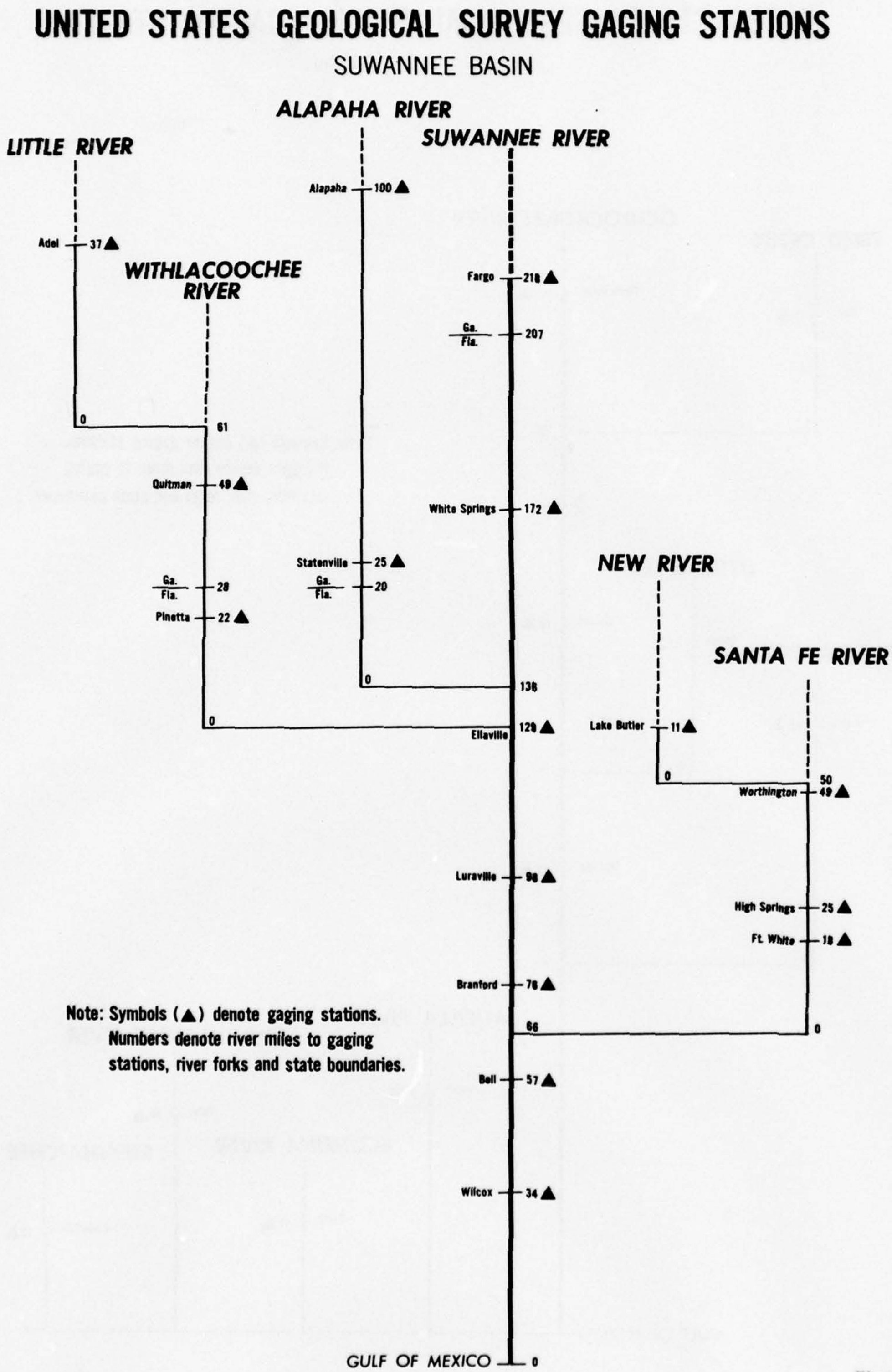


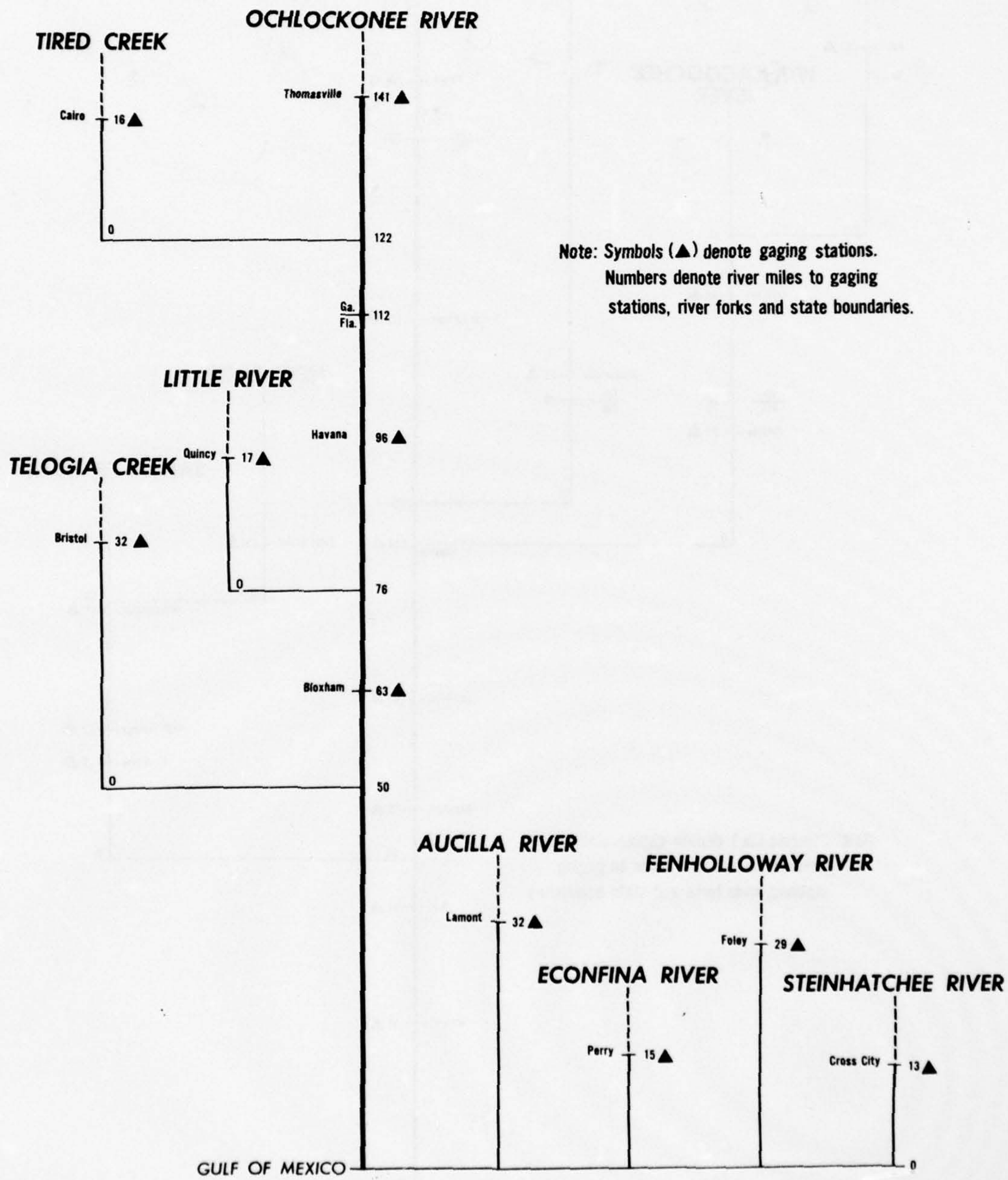
Figure 3.6



Note: Symbols (▲) denote gaging stations. Numbers denote river miles to gaging stations, river forks and state boundaries.

Figure 3.7

UNITED STATES GEOLOGICAL SURVEY GAGING STATIONS
OCHLOCKONEE BASIN



Note: Symbols (▲) denote gaging stations. Numbers denote river miles to gaging stations, river forks and state boundaries.

Figure 3.8

UNITED STATES GEOLOGICAL SURVEY GAGING STATIONS

APALACHICOLA-CHATTAHOOCHEE-FLINT BASINS

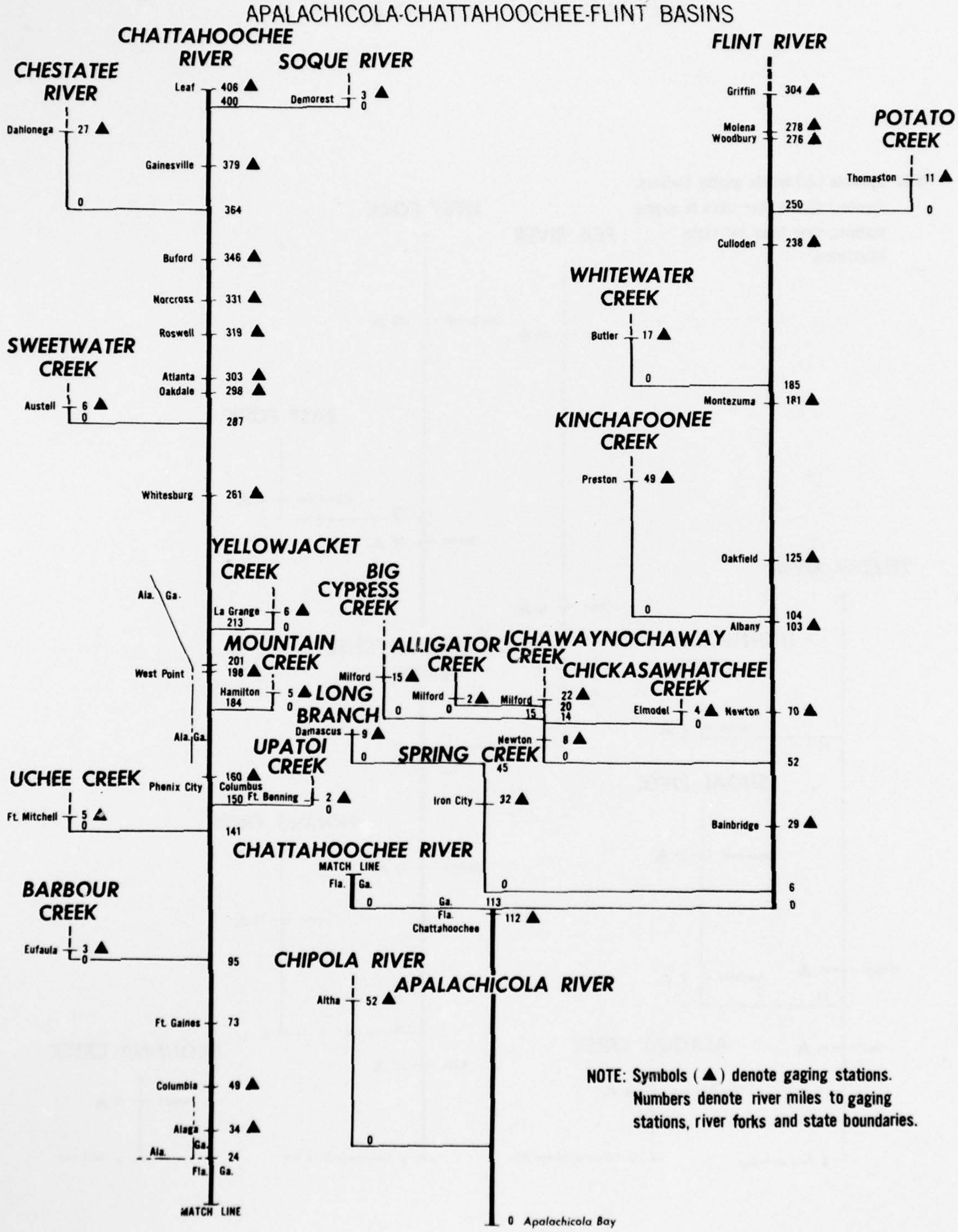


Figure 3.9

UNITED STATES GEOLOGICAL SURVEY GAGING STATIONS

CHOCTAWHATCHEE-PERDIDO BASINS - 1

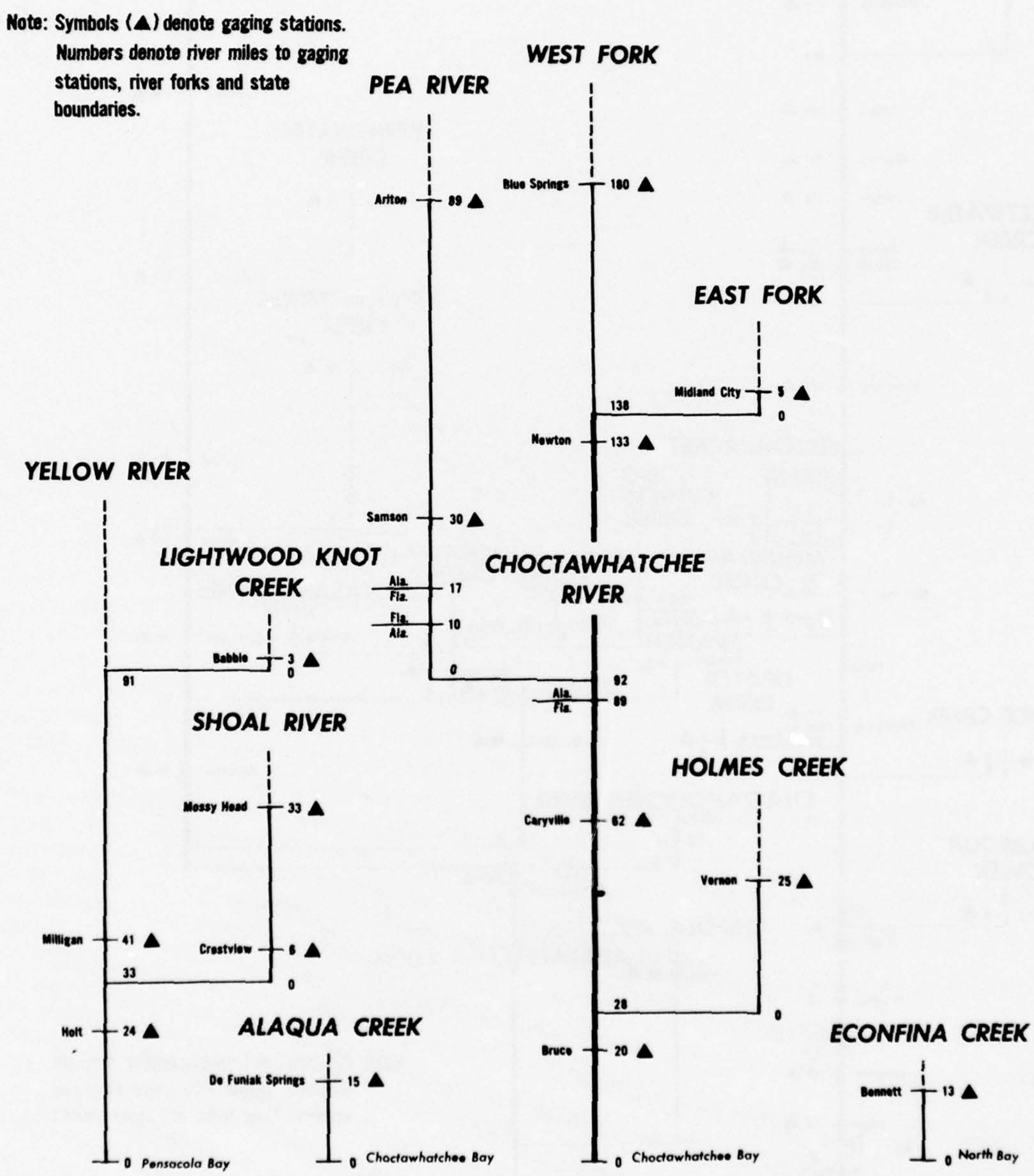


Figure 3.10

UNITED STATES GEOLOGICAL SURVEY GAGING STATIONS

CHOCTAWHATCHEE-PERDIDO BASINS - 2

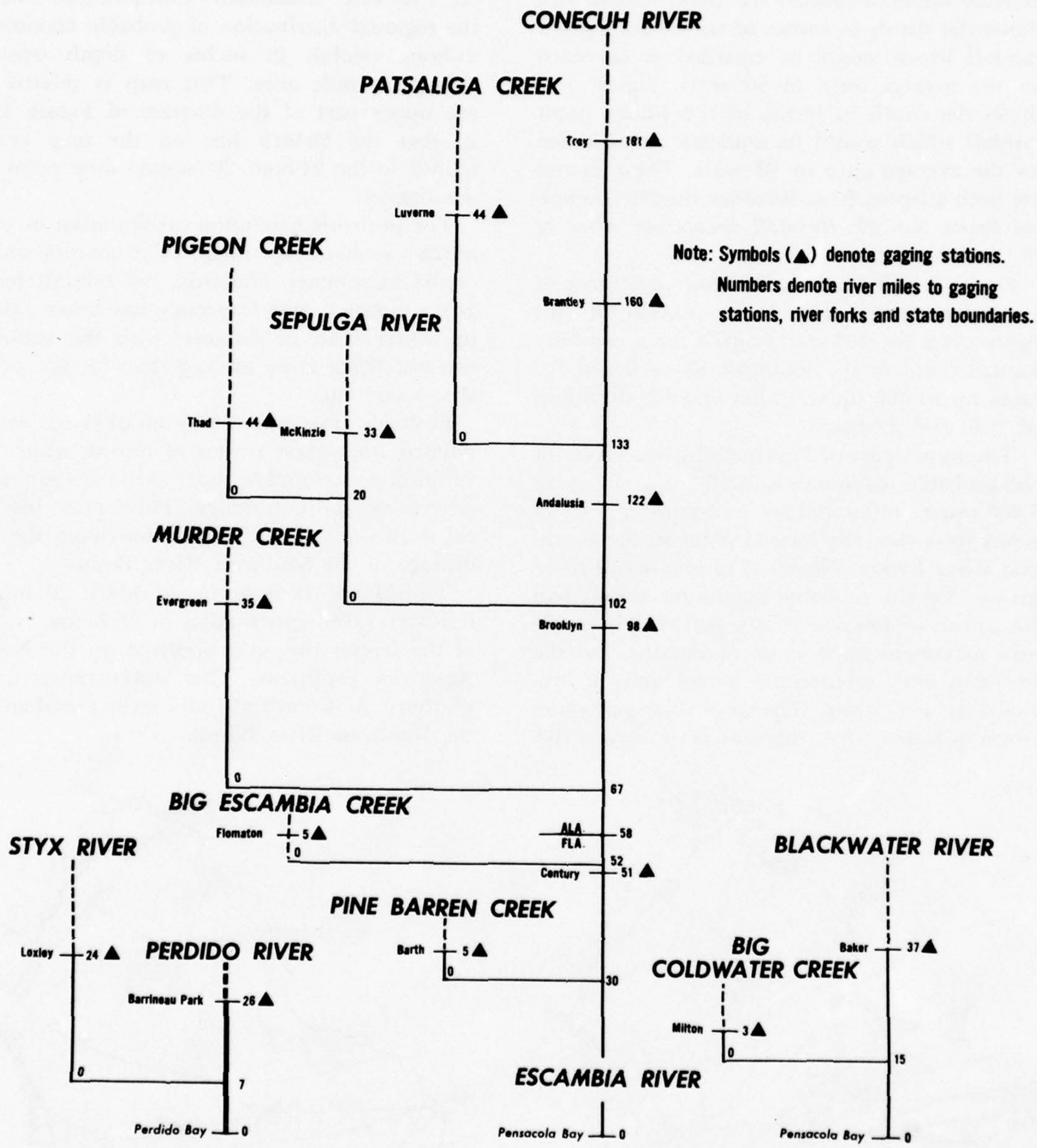


Figure 3.11

SECTION II – FLOOD-PRODUCING STORMS

To aid in estimating flood potentialities from ungaged drainage areas and from drainage areas with short records, estimates of frequencies and extreme values of rainfall are useful. Figure 3.12 shows the depth in inches of the 24-hour point rainfall which would be equalled or exceeded on the average once in 50 years. Figure 3.13 shows the depth in inches of the 1-hour point rainfall which would be equalled or exceeded on the average once in 10 years. These figures are both adapted from Weather Bureau Technical Paper No. 40, *Rainfall Frequency Atlas of the United States.*

Figure 3.14 introduces the concept of area in rainfall extremes. The lower portion of this figure gives the 100-year rainfall for a centrally located point in the Southeast River Basins for areas up to 500 square miles and for durations of 1, 6, and 24 hours.

The upper part of Figure 3.14 gives values of the probable maximum rainfall for areas up to 1,000 square miles and for durations of 6 to 48 hours for a centrally located point in the Southeast River Basins. The effect of area seems to be greater for the probable maximum storm than for storms of 100-year return period. The probable maximum storm is storm-centered, but the area-frequency relationship is not and, accordingly, is less steep. The probable maximum storm is four or five times as large as the 100-year storm for the same area and duration.

Figure 3.15, which is adapted from Weather Bureau Hydrometeorological Report No. 33 on Probable Maximum Precipitation, shows the regional distribution of probable maximum 24-hour rainfall in inches of depth over a 200-square mile area. This map is related to the upper part of the diagram of Figure 3.14 in that the 30-inch line on the map corresponds to the 24-hour 200-square mile point in the diagram.

The probable maximum precipitation in wintertime is about two-thirds the maximum which occurs in summer. Similarly, the rainfall for a given duration and frequency has lower values in winter than in summer, with the seasonal contrast being more marked than for the probable maximum.

Probable maximum precipitation is extrapolated from great storms of record, which, in addition to streamflow data, aid in determining criteria for spillway design. Three great historical storms are noteworthy in describing the hydrology of the Southeast River Basins.

The March 1929 storm, in which 20 inches fell over 2,000 square miles in 48 hours, is one of the largest that ever occurred on the North American continent. This storm centered in southeast Alabama and could recur anywhere in the Southeast River Basins.

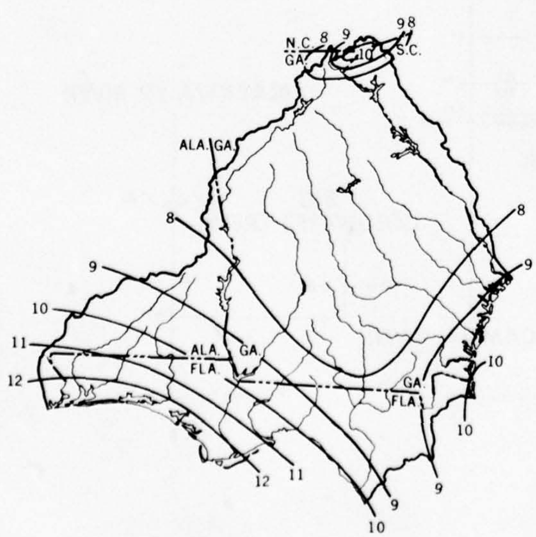


Figure 3.12 *50-Year, 24-Hour Rainfall, Inches.*

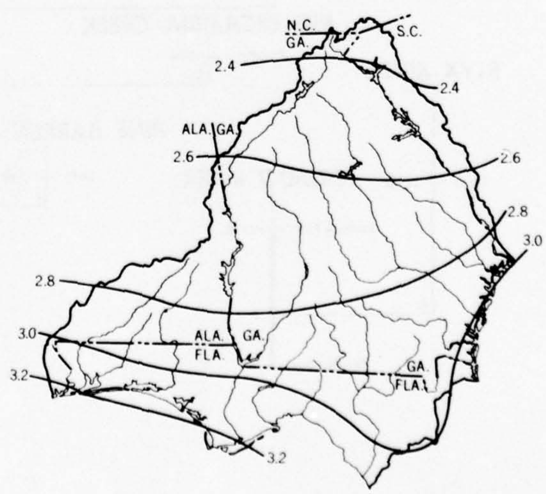


Figure 3.13 *10-Year, 1-Hour Rainfall, Inches.*

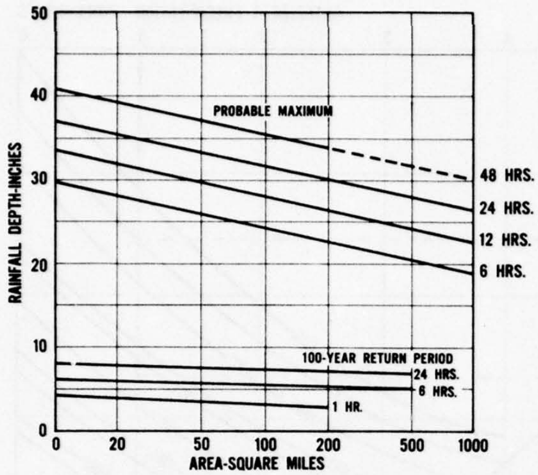


Figure 3.14 *Duration-Area Depth of Extreme Rainfall.*

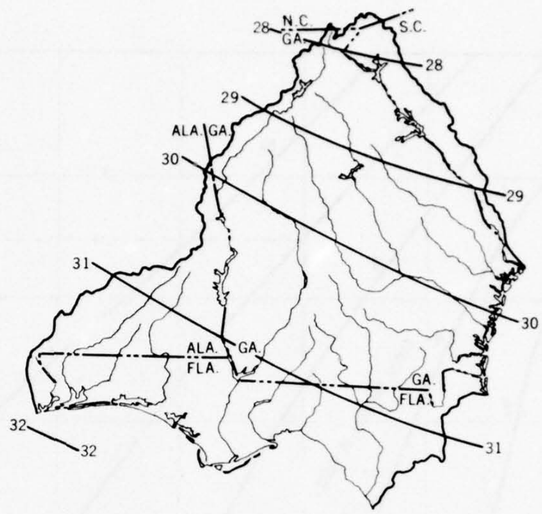


Figure 3.15 *Probable Maximum 24-Hour Rainfall, Average Depth over 200 Square Miles, Inches.*

The September 1929 storm, centered in eastern Georgia, produced an average depth of 15 inches of rainfall in 48 hours over an area of 2,000 square miles. This storm was followed in 4 days by another nearly as great over the same area.

These three storms are mentioned here to give an indication of the storm potentiality in the Southeast River Basins, both as to total magnitude and as to possible sequence of large storms. These storms caused severe flooding over much of the Southeast River Basins.

SECTION III – FLOODS

Rainfall-Runoff Relations

The physical production of floods may be represented by a graphical procedure which is used for forecasting and for estimating hypothetical floods. An example of part of such a procedure is given on Figure 3.16. Here the factors which determine the volume of runoff are seen to be antecedent precipitation, time of year, and storm rainfall. In this example, the antecedent precipitation index is a measure of antecedent rainfall, taking into account the diminishing effect of antecedent rainfall with increased time between it and the storm rainfall. The greater and more recent the antecedent rainfall, the wetter the soil and the greater the proportion of runoff from a given rainstorm.

The effectiveness of antecedent rain is different at different times of year. In late winter and early spring, the soil stays wet much longer after a rain than it does in summertime because of slower evaporation and transpiration loss from the soil. Accordingly, the same amount of rain produces a greater runoff volume in late winter than in summer.

The dashed lines on Figure 3.16 show the use of this diagram for two hypothetical examples, one for July and one for late October, each having the same antecedent precipitation and the same storm rainfall. This type of rainfall-runoff relationship is used by the Weather Bureau for forecasting streamflow in the Southeast River Basins area. The degree to which the choice of variables and the manner of combining them accurately portrays flood runoff is indicated by the fact that, with historical data, the error is less than 0.15 inches runoff two-thirds of the time.

After the volume of runoff has been estimated, it is distributed on a time scale by means of an empirically defined or synthetic unit hydrograph to produce the runoff hydrograph.

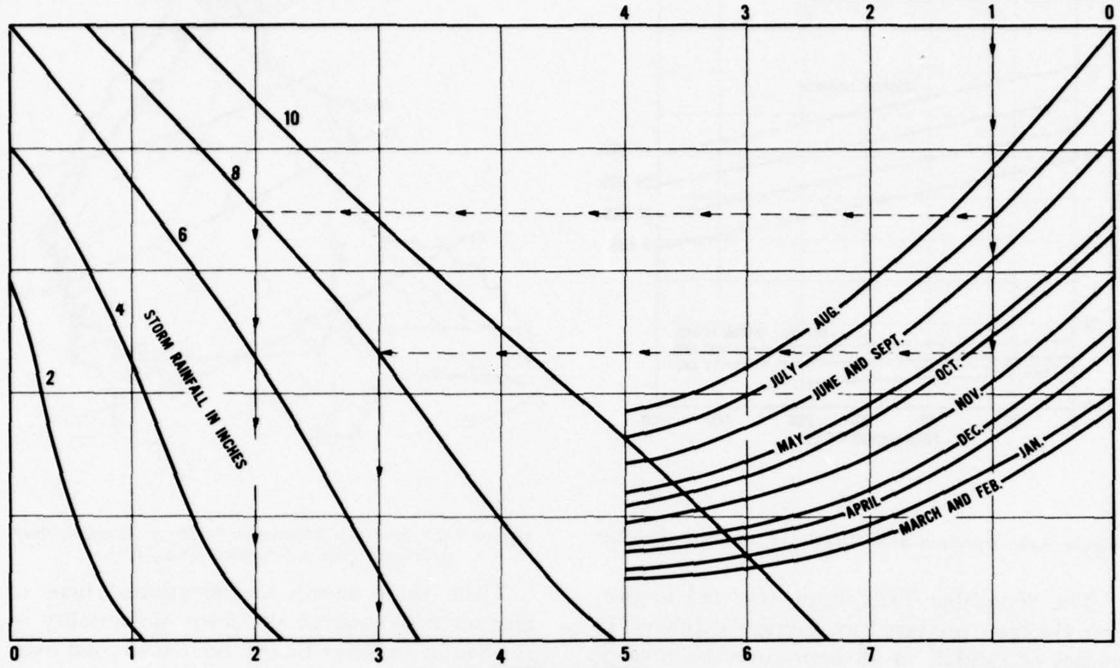


Figure 3.16 *Rainfall-Runoff Relationship.*

After the runoff hydrograph has been estimated from rainfall for headwater areas, the flow is routed and combined with tributary flow for estimating floods downstream.

Flood Volumes

Flood magnitudes are usually expressed in terms of peak rates of flow as exemplified in parts of Table 3.1. Later in this Section, generalized information on flood peak magnitudes will be presented and discussed. In planning for structures to store floodwater, it is necessary to estimate not only peak rates of flow but also the volume of floodwater that must be stored to be released at various rates of outflow.

The central problem in estimating flood volumes for broad regional planning is that of generalizing for ungaged areas. The generalization should account for the effects of pertinent physical parameters and should be expressed in terms of frequency and duration. Several approaches are available and have been used in various expedient manners for planning.

One approach is through such relationships as given on Figure 3.16. These relationships are available only for drainage areas of about 500 square miles or more. On these areas, the existing combined effects of vegetation, soil, and geology have been expressed in the form of graphs such as Figure 3.16. The effects are empirically defined and verified as relatively permanent characteristics of a large drainage area. In the eastern United States, on areas of 500 square miles or more, net changes in land and water use have had too little influence on the rainfall-runoff characteristics to be evidenced in the graphical model. Figure 3.17 shows a simplified expression of average runoff from 100-year, 24-hour rainfall, average antecedent rainfall, and early spring runoff season, for generalized 1,000-square mile drainage areas. This figure does not include the relatively small base-flow component of total flood flow. For smaller areas and longer-duration storms, the values given in Figure 3.17 would be larger than they are.

A second approach, previously used for drainage areas up to about 15 square miles in the Southeast River Basins, is the U. S. Soil Conservation Service curve-number method, in which emphasis is given to agricultural knowledge in assessing the effects of different soils, land use,

and vegetative cover on the rainfall-runoff relationship. In practice, the U. S. Soil Conservation Service flood prevention dams in this region store about 5 inches average depth of runoff from the drainage area.

A third approach is interpolation among sparse data already available for nearby sites where it is believed that the physical conditions of the soil, vegetation, and geology are consistent.

A fourth approach, commonly used by the Corps of Engineers, uses an estimated infiltration index determined by the difference between observed rainfall and runoff for prototype drainage areas.

Ideally, available gaging station data could be analyzed statistically on a duration-frequency-volume basis to provide a wider base for such interpolation than is now available. Having this, a systematic analysis of the physical factors would provide for objective estimates for ungaged areas where measures of the pertinent physical factors can readily be incorporated. This would be a tremendous job.

For flood volumes the important influence of duration multiplies the magnitude of the job in requiring a search of the record for maximum 10-day, 30-day, and other durations of runoff for each year. By contrast, the analysis and generalization of flood-peak data involves, usually, already published values of annual flood peaks. The Corps of Engineers has made a helpful start in analyzing flood volume data from 108 gaging stations throughout the United States, of which 3 are in the Southeast River Basins and 6 more in adjoining areas. To complete this job, data from many more stations should be analyzed statistically and then generalized in terms of regional and physical parameters for use with ungaged sites. The U. S. Geological Survey has compiled and is beginning to generalize large amounts of observed flood-volume data.

In the absence of a regional generalization, it has been necessary to use combinations of the approaches cited above.

Flood Peak Magnitudes

The great rainstorm and flood of March 1929 in southeastern Alabama are exemplified for the Choctawhatchee basin above Caryville, Florida, in Figure 3.18. Both the rain and the flood resulting from it are shown in total inches and inches per day, average depth over the drainage area. The runoff is given also in cubic feet per second. The runoff values were estimated by rating curve extensions. This was an outstanding flood and shows a typical relationship between a flood-producing storm and the resulting runoff, in this case with a 3-day lag between the rain peak and the flood peak and a spreading out of the runoff over a period of about 10 days.

This flood of March 1929 is identified as the greatest flood of record in the upper left diagram of Figure 3.19, which shows for four selected

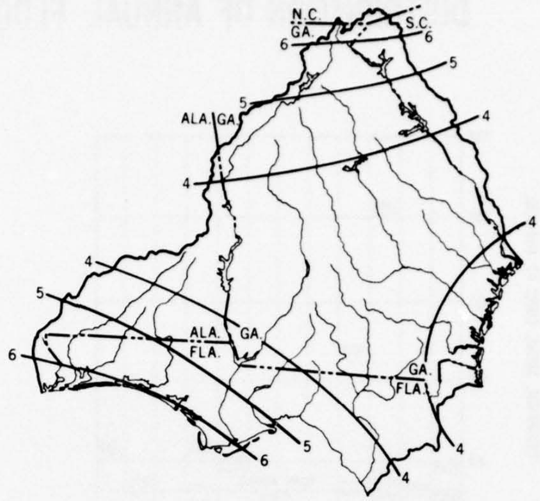


Figure 3.17 *Generalized Runoff Volumes from 100-Year, 24-Hour Rainfall, Average Depth in Inches.*

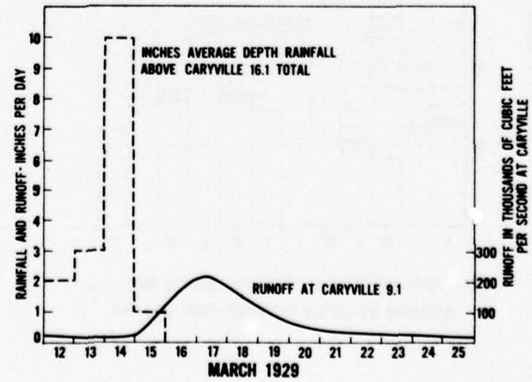


Figure 3.18 *Rainstorm and Flood of March 1929.*

DISTRIBUTION OF ANNUAL FLOOD PEAKS BY CALENDAR MONTH

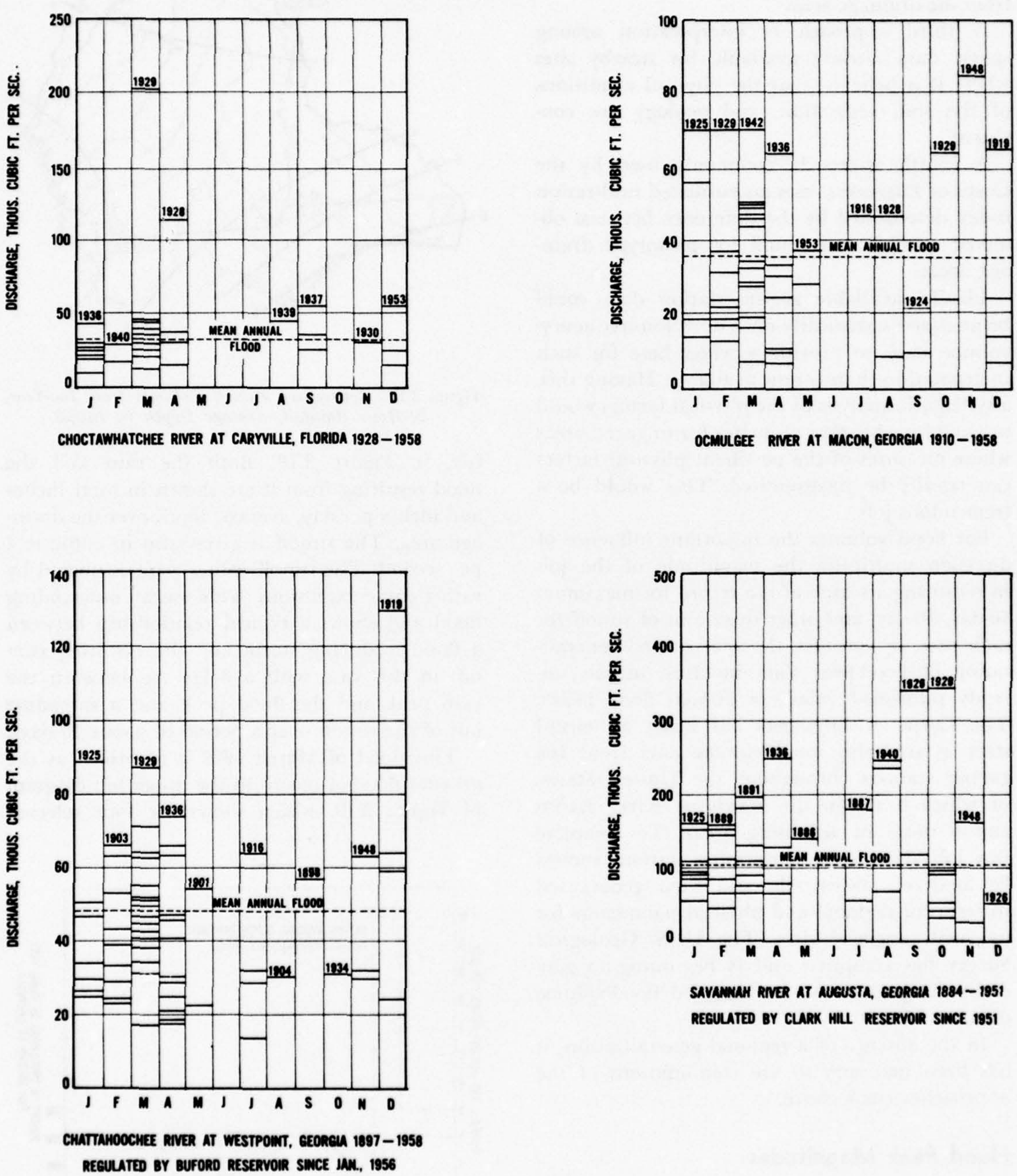


Figure 3.19

streamflow stations, the magnitude and calendar month of each annual flood of record—the annual flood being the greatest peak flow for each water year. The maximum flood for each month is identified by year of occurrence. This figure and others which have been prepared, but not published, show that, while floods can and do occur at any time of year, they, like average monthly flows, tend to be concentrated in the winter and early spring.

Figure 3.20 shows the relationship between the peak flow of outstanding floods of record in and near the Southeast River Basins, and their respective drainage areas. The Choctawhatchee River at Caryville, whose record flood of March 1929 has been cited earlier, is identified as Point No. 15 in this figure. Table 3.2 lists the number, station, and date of floods shown on Figure 3.20. The Myers and Creager Lines were used for generalized spillway criteria which are discussed more fully in Part Five, Section IV—Spillway Criteria.

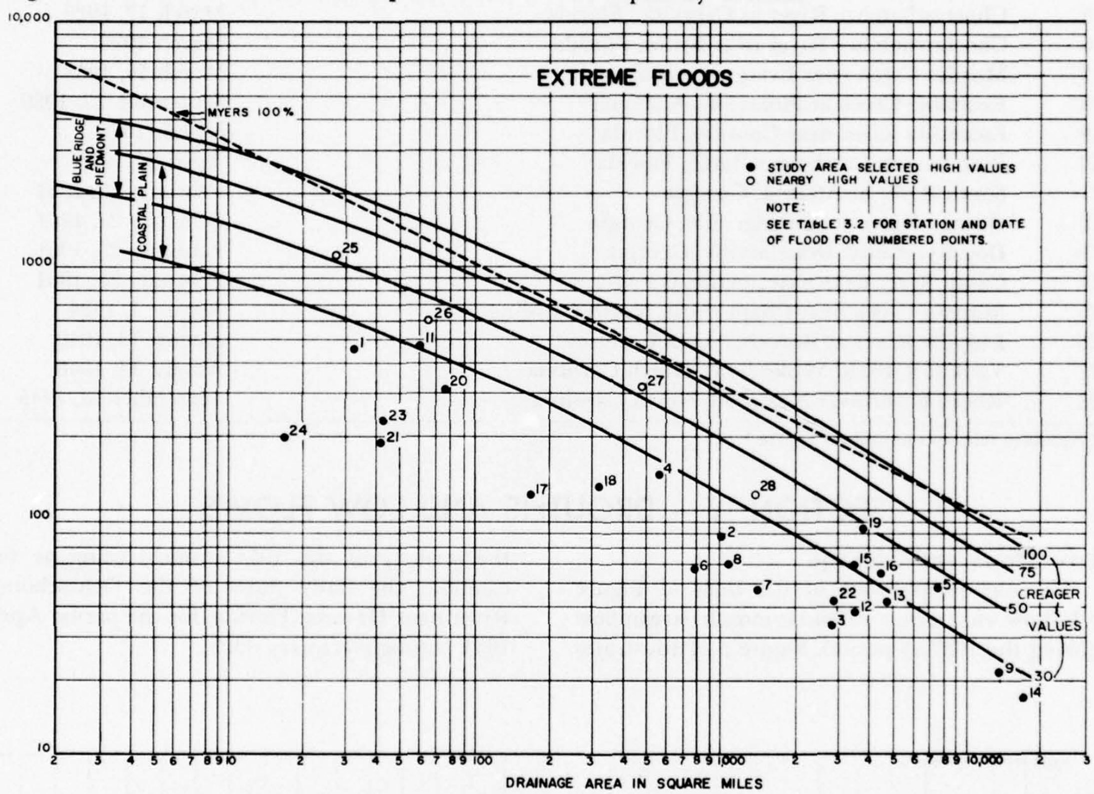


Figure 3.20 *Extreme Floods of Record.*

TABLE 3.2
Extreme Floods of Record

No.*	Stream and station	Date of flood
1	Panther Creek near Toccoa, Georgia	June 16, 1949
2	Seneca River near Anderson, South Carolina	August 17, 1928
3	Savannah River near Calhoun Falls, S. C.	August 13, 1940
4	Little River near Lincolnton, Georgia	September 28, 1929
5	Savannah River at Augusta, Georgia	October 3, 1929
6	Ogeechee River at Louisville, Georgia	October 1929

(continued)

TABLE 3.2—Continued

No.*	Stream and station	Date of flood
7	Ocmulgee River near Jackson, Georgia	December 11, 1919
8	Oconee River near Greensboro, Georgia	August 26, 1908
9	Altamaha River at Doctortown, Georgia	January 23, 1925
10	Wildcat Creek near Lawrenceville, Georgia	May 6, 1956
11	Tired Creek near Cairo, Georgia	April 1, 1948
12	Chattahoochee River at West Point, Georgia	December 10, 1919
13	Chattahoochee River at Columbus, Georgia	March 15, 1929
14	Apalachicola River at Chattahoochee, Florida	March 20, 1929
15	Choctawhatchee River at Caryville, Florida	March 17, 1929
16	Choctawhatchee River near Bruce, Florida	March 1929
17	Murder Creek near Evergreen, Alabama	March 16, 1938
18	Escambia Creek at Flomaton, Alabama	September 27, 1939
19	Escambia River near Century, Florida	March 1929
20	Pine Barren Creek near Barth, Florida	April 14, 1955
21	South River at Atlanta, Georgia	February 25, 1961
22	Oconee River at Milledgeville, Georgia	February 25, 1961
23	Dog River near Douglasville, Georgia	February 25, 1961
24	Camp River near Fayetteville, Georgia	February 25, 1961
25	Morgan Creek near Chapel Hill, North Carolina	August 4, 1924
26	Linville River at Branch, North Carolina	August 13, 1940
27	Yadkin River at Wilkesboro, North Carolina	August 14, 1940
28	Rocky River near Norwood, North Carolina	September 18, 1945

* Numbers refer to numbers in Figure 3.20.

SECTION IV – DROUTHS AND LOW FLOWS

Low Flows and Storage

The narrow portions of the lines of Figure 3.1 show the lowest calendar-month streamflow during the 1937-55 period. Figure 3.21 illustrates the severity of the 1954 drouth, using as the example the daily flows of the Ochlockonee River near Havana, Florida, for the period April 1954 through January 1955.

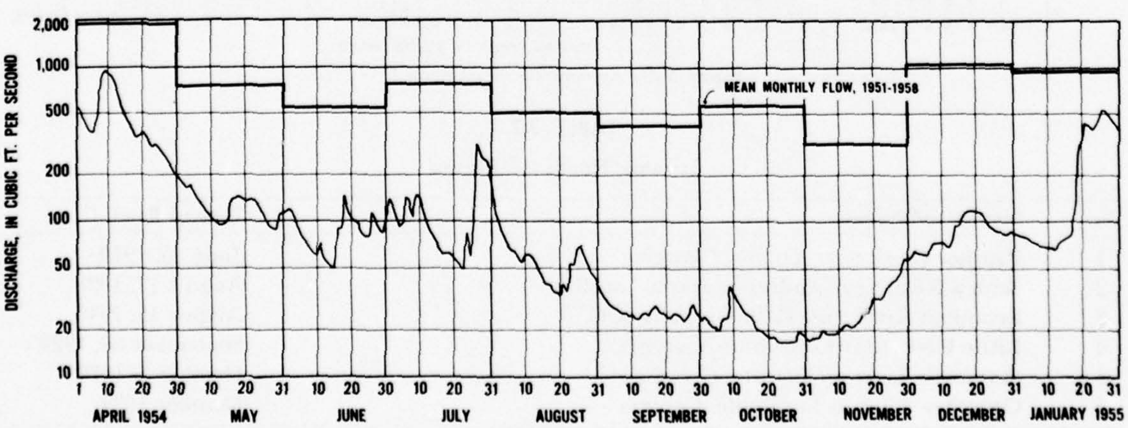


Figure 3.21 *Record Low Flow of Ochlockonee River at Havana, Florida.*

Note that the discharge scale is logarithmic and that the October flow in 1954 was about 1/25 the average flow for the calendar month.

It is well known that the essential problem and opportunity of flow regulation is storing excess flows for release during times of otherwise deficient flow. How to accomplish this in a physically feasible and economical manner is the essence of surface-water resource planning. Having defined the needs for water, it is helpful to employ graphical methods for relating the required amount of storage to the low-flow experience of given streams. Recalling the sparsity of data, as shown on the map of Figure 3.2, it has been possible nevertheless to generalize a procedure for estimating storage requirements in the study area.

Figures 3.22 and 3.23 show draft-storage relationships prepared by the U. S. Geological Survey for the Piedmont and Blue Ridge, and the Coastal Plain provinces, respectively, in standard measure of storage and flow per square mile of drainage area for the 1954 drouth, using the additional parameter of minimum flow during 1954. To use these diagrams, it is necessary to decide what minimum flow or draft is required, enter the appropriate diagram with the observed or estimated minimum flow of 1954, and determine the interpolated value of required storage from the curved lines in the diagram. In Table 3.1, the median and extreme annual low flows are given for about 160 gaging stations.

Estimates have been made of the 10-year, 7-day low flows for a number of sample stations, and generalized draft-storage relationships have been prepared for an estimated 10-year return period. Figure 3.24 is the set of draft-storage relationships, and the map of Figure 3.25 shows the eight basins and three water-storage areas required for use of Figure 3.24. Areas D and E of the map of Figure 3.25 are excluded from the generalized system of curves on Figure 3.24 because of sinkholes and other local phenomena. In general, minimum flows occur in autumn. No attempt was made to evaluate the incidence of low flows for other times of the year.

In addition to the values of low flows given in Table 3.1 and the draft-storage curves, it is helpful to examine the flow-duration curves of Figure 3.28. These four curves typify the flow regime in the physiographic provinces represented by the stations shown.

The effect of storage may be shown by two such curves for the same point, one with and one without storage. An example is given in Figure 3.27 in which the flow of the Savannah at Augusta, Georgia, is shown for the periods before and after construction of Clark Hill Reservoir.

Soil Moisture

During a year of average total rainfall, there are usually periods of several days duration between rains when soil moisture gets so low that pasture grasses and small crops tend to wilt.

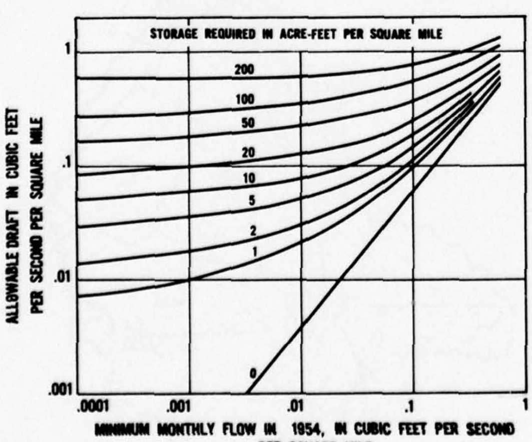


Figure 3.22 *Draft-Storage Curves for 1954, Blue Ridge and Piedmont Provinces.*

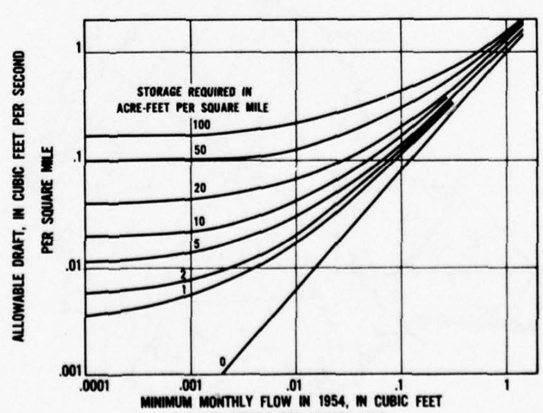


Figure 3.23 *Draft-Storage Curves for 1954, Coastal Plain Province.*

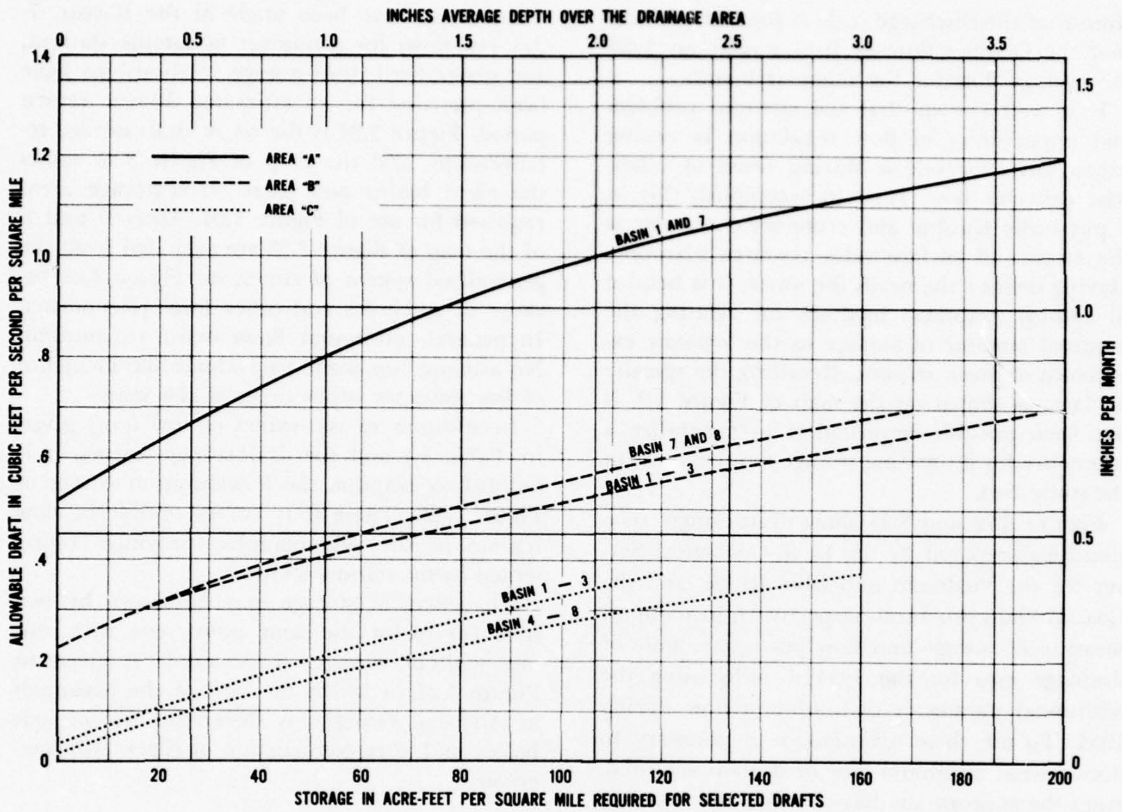


Figure 3.24 *Draft-Storage Curves for 10-Year, 7-Day Low Flows.*

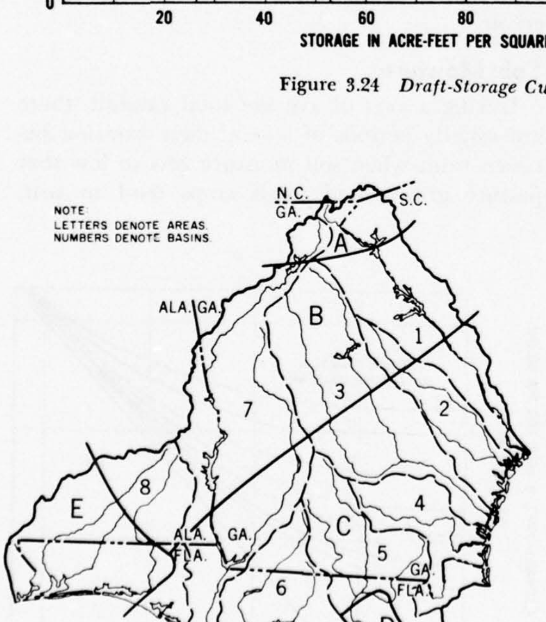


Figure 3.25 *Draft-Storage Area Map.*

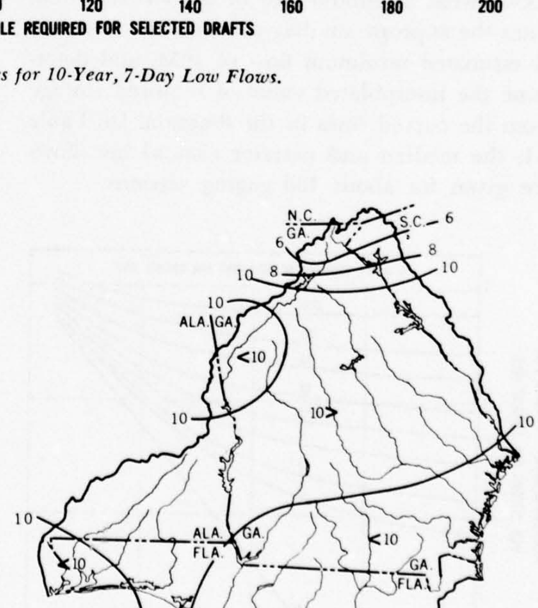


Figure 3.26 *Soil-Moisture Deficit, One Year in Ten, Inches Average Depth.*

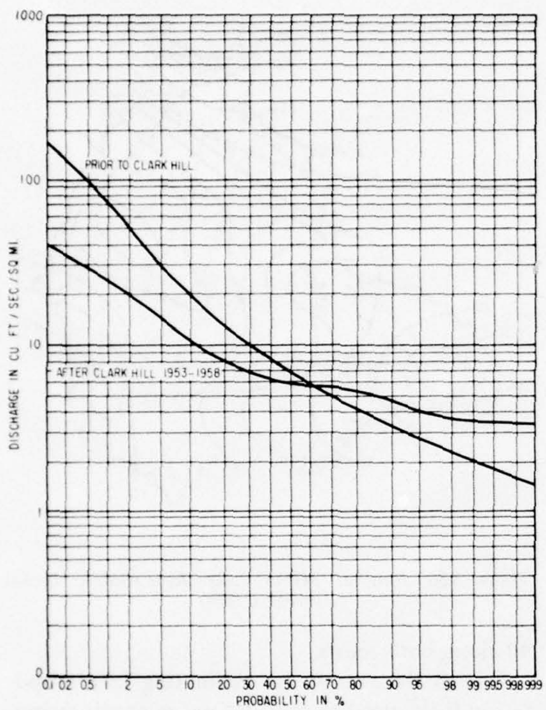


Figure 3.27 *Flow-Duration Curve for Savannah River at Augusta, With and Without Storage.*

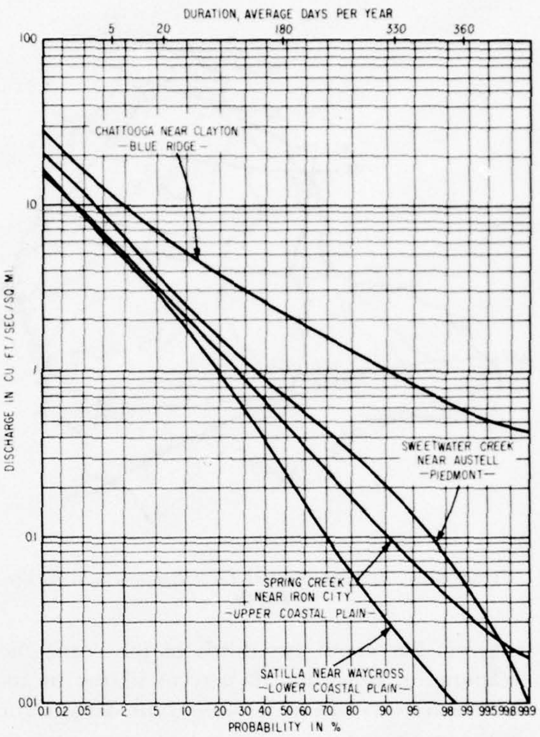


Figure 3.28 *Typical Flow-Duration Curves.*

Over most of the Southeast River Basins, it has been estimated that this soil moisture deficiency can be overcome by properly timed application of a total of 6 inches of supplemental irrigation. One year in ten, the amount of supplemental irrigation required is 10 inches over much of the Southeast River Basins. The map of Figure 3.26, after Van Bavel, portrays the regional pattern of soil moisture deficit equalled or exceeded on the average of one year in ten in inches of average depth over the ground. The foregoing is based on reasonable assumptions as to uniform soil characteristics, empirical weather data, and widely accepted methods for estimating evapotranspiration from vegetated land areas. Maps similar to Figure 3.26 could be prepared and irrigation requirements determined for various land use and soil types and for a range of frequencies for any place in the Southeast River Basins.

SECTION V – EVAPOTRANSPIRATION

It is necessary in this discussion to distinguish not only between evaporation and transpiration, but also among pan evaporation, lake evaporation, average transpiration, and transpiration for a given season or other period. Pan evaporation is rather widely observed, but its relation to lake evaporation is not as simple as had been thought in earlier years. The difference in heat storage and other factors leads to pan coefficients which vary seasonally and in other ways. By proper consideration of observed pan data and of meteorological factors involved in the exchange of water vapor and heat, generalized maps of mean annual lake evaporation have become possible. Such a map showing average annual lake evaporation for the period 1945-55 for the Southeast River Basins is given on Figure 3.29, from Weather Bureau Technical Paper No. 37, *Evaporation Maps for the United States*. Lake evaporation varies appreciably from year

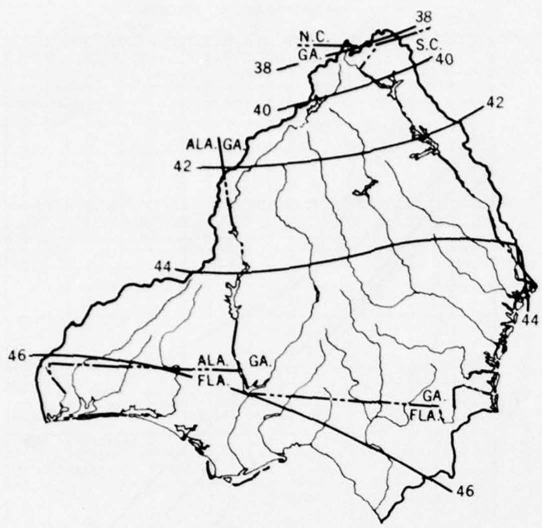


Figure 3.29 *Average Annual Lake Evaporation. Inches Depth.*

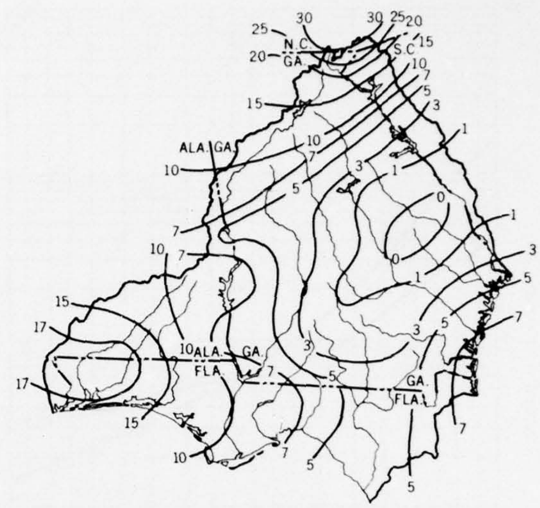


Figure 3.30 *Rainfall Minus Lake Evaporation, Inches Average Depth.*

to year. For about two-thirds of the years, the evaporation is within 10 percent of the mean. Nineteen years out of 20 are within 20 percent of the mean.

For a natural land surface, it is practically impossible to separate evaporation from transpiration; therefore, they are combined as evapotranspiration (ET).

Mean annual ET, conceptually, is a residual, the difference between rainfall and runoff, with allowance for interbasin ground water exchange which in most terrane is believed to be relatively small. Ground water recharge is balanced by pumping, natural contributions from ground to surface flow, and subterranean flow into the ocean. Practically, to prepare a map of mean annual ET, a detailed map of mean annual rainfall is necessary, also a detailed map of mean annual runoff. As shown by the map on Figure 3.2, there are gaps in the runoff data which make a map showing isolines of runoff difficult to prepare. If a map of mean annual ET were to be drawn, its generalized values would range from about 30 inches in the mountains to about 40 along both coasts.

One of the reasons for estimating lake evaporation is the need to consider net reservoir evaporation in planning water availability. Net reservoir evaporation is the difference between evaporation from the reservoir surface and the ET that would occur from the natural land surface which would be, or is, occupied by the reservoir. The map of Figure 3.30, rainfall minus evaporation, has been used in making estimates of net reservoir evaporation in the Southeast River Basins, and the values shown there were subtracted from estimated runoff from the reservoir area for conditions prior to construction of the reservoir. This is discussed in more detail in Part Four, Section V.

Inasmuch as most reservoirs have an area which is a small fraction of the total drainage area, net reservoir evaporation can be neglected in many instances in the Southeast River Basins except in extended drouth periods. These losses would be well within the error of estimating runoff for ungaged areas, or estimating seepage, or other losses.

SECTION VI — WATER QUALITY

The U. S. Public Health Service report of 1961 to the U. S. Study Commission, "Water Quality Basic Data, Southeast River Basins," contains detailed information on water quality. To summarize, some general statements are made here as to hardness, color, temperature, suspended sediment load, and pollution. Water quality data of all kinds are sparse and scattered.

Hardness, in equivalent $CaCO_3$, of water in streams in the area is generally less than 50 parts per million, ranging from less than 10 over large areas to more than 100 for certain smaller areas. Water in streams throughout the United States is generally much harder, averaging about 300 parts per million. Differences in hardness are influenced by the amount of water and duration of its contact with various types of minerals. Hardness of ground water at any one location may vary with depth. Hardness of water in streams varies with size and rate of flow of the stream and with differences in local geology.

The total hardness of ground water is given in Table 3.3, based on 500 individual and average sets of data, taken at various brief periods at different sites.

The natural acidity or alkalinity of the surface water and ground water of the entire Southeast River Basins, as expressed on the pH scale, is very nearly 7.0, neutral. Ninety-two percent of the surface data and 81 percent of the ground water data are within the range of 6.0 to 8.0.

In the Lower Coastal Plain, water in the streams is typically dark from tannins of vegetative origin. In the tidal estuaries, over an average distance of as much as 20 miles from the mouth of many streams, the tidal action, particularly at times of low flow, produces an appreciable degree of salinity in the surface water.

The natural temperature in large streams is near the average monthly air temperature; the mixing and heat storage of the large amount of water dampens out day-to-day fluctuations. In smaller streams, day-to-day fluctuations in water temperature are observed and in the smallest streams, hour-to-hour variations in temperature are evident, with the daily range of temperature being nearly as great as for the nearby air. Stream temperatures are affected by certain types of reservoir operation and by return flow of water diverted for condenser cooling and similar purposes. Ice is rare in streams and lakes in the Southeast River Basins, even in much of the mountain region.

The concentration of suspended sediment in Piedmont and Blue Ridge streams probably averages 100 to 1,000 parts per million or more and in the Coastal Plain 10 to 100 parts per million. These estimates are based on very sparse data. Averages of sparse sediment load data may be misleading because the load varies so greatly with the rate of flow and with varying local conditions. No bedload data have been found for the study area. Turbidity of major Piedmont streams observed at intakes of several Georgia waterworks plants has declined markedly during the period 1940 to 1960 and in 1960 averaged about 40 parts per million.

In general, the temperature of water taken from the ground is about the same as the mean annual air temperature. Exceptions are water from very shallow wells or from very small springs, in which the water temperature varies seasonally, and a few warm or hot springs, some of which are well known. The temperature of most of the ground water ranges from 64 to 69 in the Coastal Plain and slightly cooler north of the Fall Line with values below 60 in the mountains.

There is an increasing number of stream

TABLE 3.3

Hardness of Ground Water
(parts per million of equivalent $CaCO_3$)

Basin	Average	Range within which two-thirds of the data occur
Savannah	45	20 to 130
Ogeechee	80	50 to 120
Altamaha	60	30 to 130
Satilla-St. Marys	200	120 to 400
Suwannee	170	120 to 250
Ochlockonee	180	120 to 300
Apalachicola-Chattahoochee-Flint	60	25 to 130
Choctawhatchee-Perdido	100	20 to 160

reaches in the study area in which pollution is becoming a serious problem. In the past, relatively low waste loadings, together with usually ample flows and good waste assimilation characteristics, have resulted in effective stream recovery from most sources of pollution. However, increasing population and industrial development and changes in streamflow regime due to the operation of various water resource developments have resulted in the degradation of water quality in some streams to the point where legitimate water uses have been curtailed.

SECTION VII – GROUND WATER

Water-Bearing Formations

In general, the area north of the Fall Line is one of drastically limited ground water supply because of its geology. The underlying rock is dense and crystalline, and water is available only in the thin soil mantle and fracture zones of the rock itself. South of the Fall Line, deep sedimentary aquifers provide unique and tremendous sources of generally good water. At points along the coast, salt-water intrusion is a problem; and inland there are scattered places where sulfur, salinity, or even poor yield limits the development. In the Coastal Plain province, ground water generally is a major source for every kind of use, and it can be obtained nearly everywhere by drilling a well and pumping.

In the Piedmont and Blue Ridge provinces, typical wells yield 5 to 25 gallons per minute and rarely yield more than 100 gallons per minute. In the Cretaceous zone, immediately southeast of the Fall Line, yields frequently range from 1,000 to 2,000 gallons per minute. In the principal artesian aquifer, which underlies about three-fourths of the Coastal Plain area, there are many large springs and wells which yield several thousand gallons per minute. Large yields are typical of the other Coastal Plain aquifers, particularly the Miocene and post-Miocene sand and gravel beds near Pensacola. The approximate areal extent and geologic age of these Coastal Plain aquifers are shown on the map of Figure 3.31.

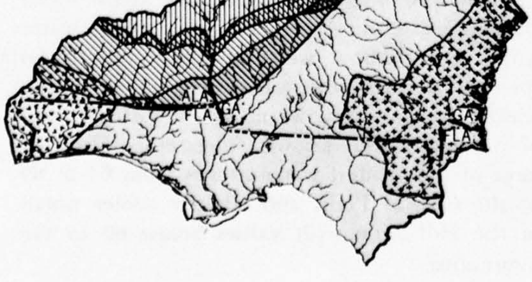


Figure 3.31 *Aquifers Below the Fall Line.*

The map of Figure 3.32 supplements that of Figure 3.31 in showing the major structural features of the Southeast River Basins and adjoining area with respect to ground water geology. It helps explain the direction of natural flow of ground water and shows the Ocala-Peninsula uplift.

Figure 3.33 shows a simplified cross-section of the Coastal Plain structure along the Atlantic coast and the movement of water through the principal artesian aquifer. Similarly, Figure 3.34 shows a cross-section of the sand and gravel aquifer of Miocene age near Pensacola. These two cross-sections are typical. Figure 3.34 is adapted from Florida Geological Survey Information Circular No. 30: Musgrove, R. H.; Barraclough, J. T.; and Marsh, Owen T.; 1961; titled "Interim Report on Water Resources of Escambia and Santa Rosa Counties, Florida." Except for a few small, inland pockets of poor quality ground water and salt-water intrusion near the coast, ample ground water can be obtained nearly anywhere in the Coastal Plain. An examination of well data disclosed that it is rarely necessary to go deeper than 700 feet to find a large supply of artesian water; that in about 95 percent of the wells, water rises to within 100 feet of the ground surface; and that in about 25

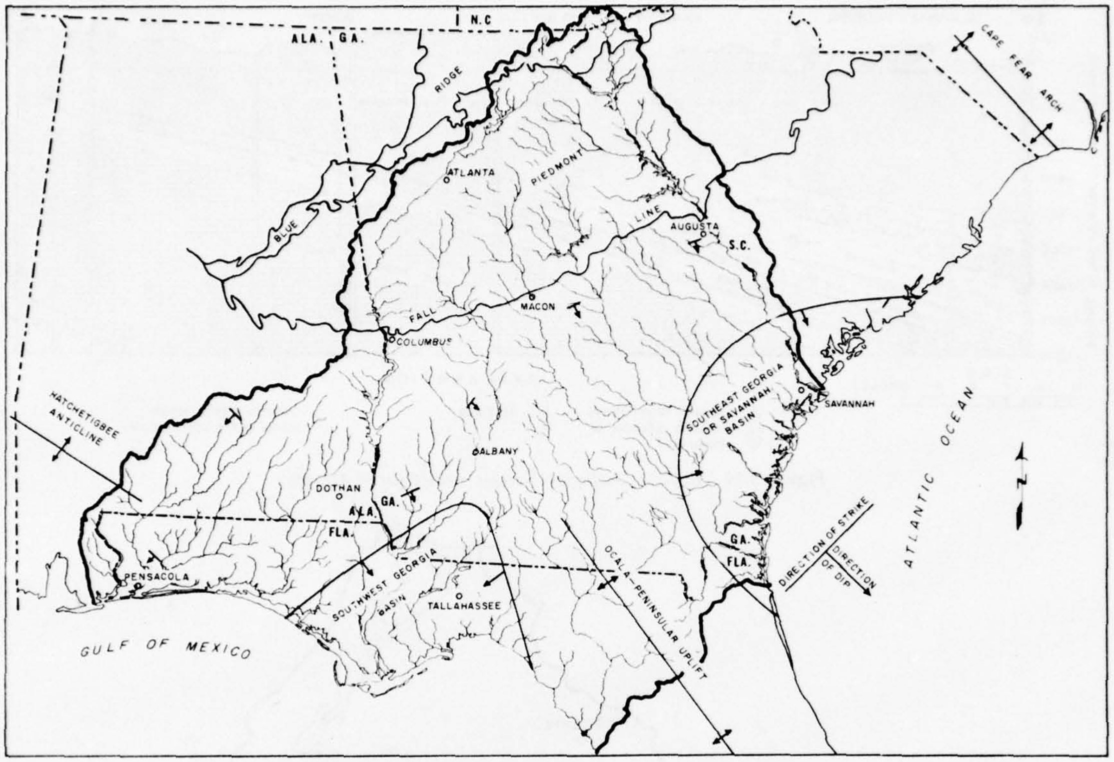


Figure 3.32 *Geological Features Relating to Ground Water.*

From: "Jekyll Island—Its Geology and Water Resources"
J. T. Callahan, Georgia Mineral Newsletter, Vol. XII, No. 2
Fall, 1959.

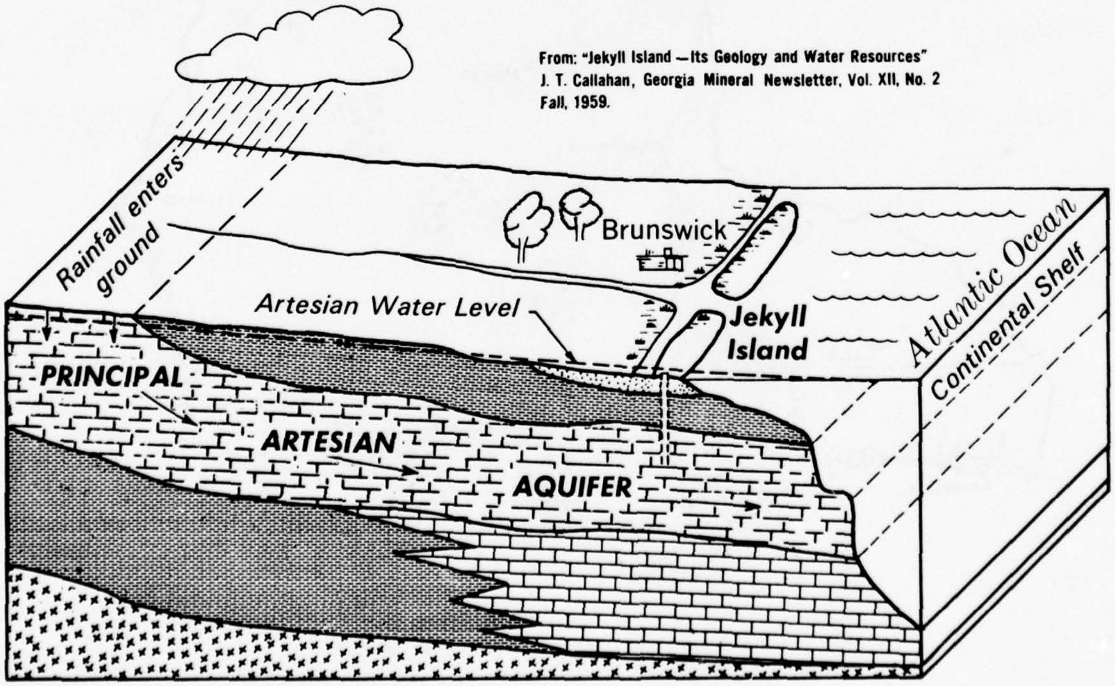


Figure 3.33 *Typical Geological Section—Atlantic Slope.*

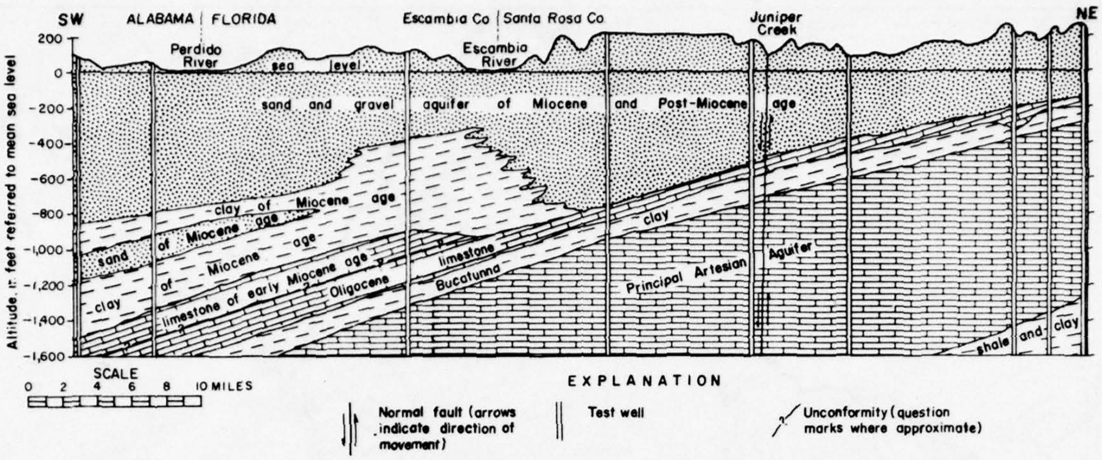


Figure 3.34 *Typical Geological Section near Gulf of Mexico.*

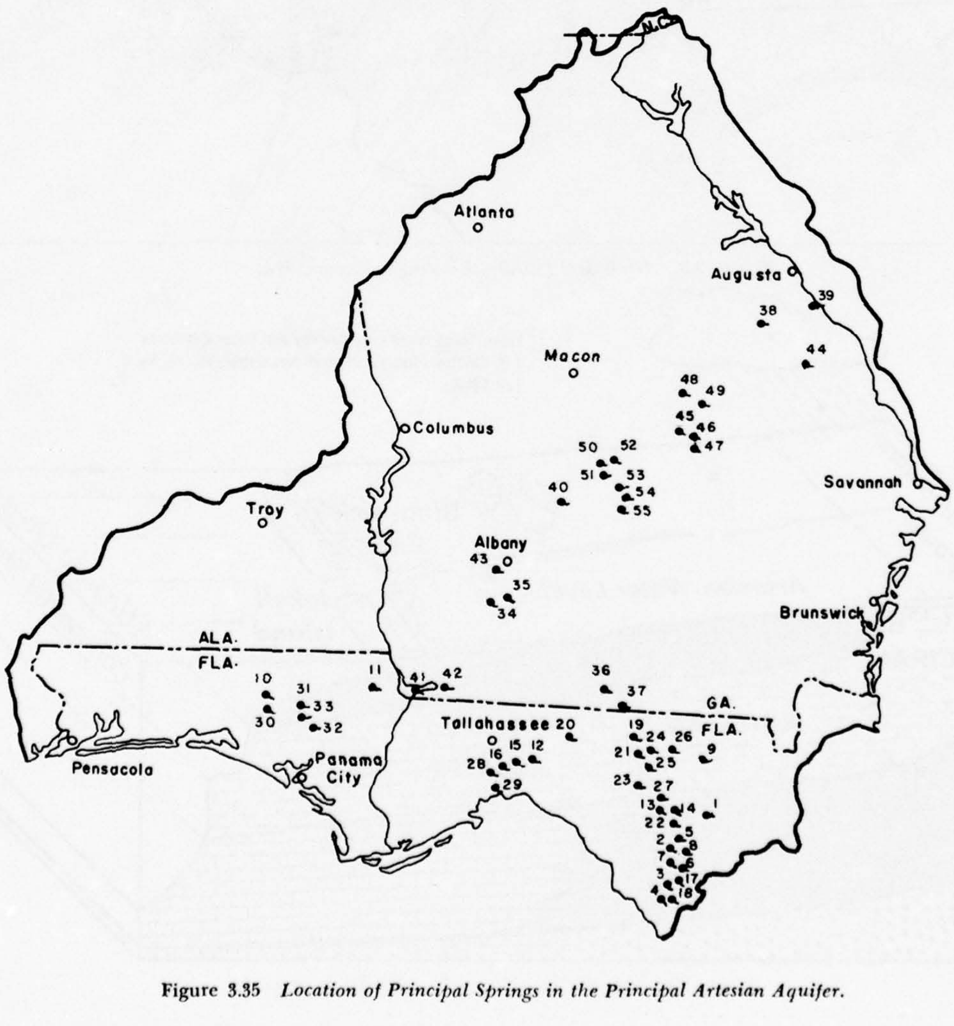


Figure 3.35 *Location of Principal Springs in the Principal Artesian Aquifer.*

TABLE 3.4
Flow of Springs from the Principal Artesian Aquifer
(See accompanying location map, Figure 3.35)

No.	State	County	Name	Flow	
				Million gallons per day	Cubic feet per second
1	Florida	Columbia	Ichetucknee	157 to 302	243 to 467
2	"	Dixie	Big Cypress	8	12.4
3	"	"	Cooper	12	18.8
4	"	"	Little Cooper	1.3	2
5	"	Gilchrist	Hart	38 to 40	58.6 to 62.1
6	"	"	Lumber Camp	1.9	3
7	"	"	Otter	3.5	5.4
8	"	"	Rock Bluff	27	42.1
9	"	Hamilton	White	23 to 46	36.2 to 72
10	"	Holmes	Ponce de Leon	12 to 13	18.1 to 20.7
11	"	Jackson	Blue	56 to 179	86.4 to 277
12	"	Jefferson	Wacissa	65+	100.8+
13	"	LaFayette	Morrison	33	51.6
14	"	"	Troy	36 to 96	55.2 to 149
15	"	Leon	Natural Bridge	74 to 85	115 to 132
16	"	"	Rhode	45	67
17	"	Levy	Fannin	70 to 88	109 to 137
18	"	"	Manatee	88 to 141	137 to 218
19	"	Madison	Blue	94	145
20	"	"	Pettis	0.1	0.15
21	"	"	Suwanoochee	19	29.6
22	"	Suwannee	Branford	6.8	10.6
23	"	"	Charles	6.1 to 24	9.4 to 36.8
24	"	"	Ellaville	27	41.2
25	"	"	Falmouth	36 to 236	59.6 to 365
26	"	"	Suwannee	3.9 to 28	6.1 to 44
27	"	"	Telford	24	37
28	"	Wakulla	River Sink	115	178
29	"	"	Wakulla	181	283
30	"	Walton	Morrison	57 to 78	89 to 121
31	"	Washington	Beckton	32	49
32	"	"	Blue	20 to 34	31.6 to 52.5
33	"	"	Cypress	55	84.9
34	Georgia	Baker	Blue	--	--
35	"	"	Lester	--	--
36	"	Brooks	Blue or Wade	15	23.21
37	"	"	McIntyre	30	46.42
38	"	Burke	Davis	--	--
39	"	"	Cox	--	--
40	"	Crisp	Cordele Town	--	--
41	"	Decatur	Russell	--	--
42	"	"	Blue	--	--
43	"	Dougherty	Radium (Blue)	2.6 to 87	4 to 135
44	"	Jenkins	Magnolia	several	--
45	"	Laurens	Well	--	--
46	"	"	Rock	--	--
47	"	"	Wilkes	--	--
48	"	"	Thundering	--	--
49	"	"	Lovett	--	--
50	"	Pulaski	Mock	6	9.28
51	"	"	Blue	3	4.64
52	"	"	Hawkinsville	3	4.64
53	"	Wilcox	Poor Robin	.4	.62
54	"	"	Abbeville Mineral	--	--
55	"	"	Osewichee	12	18.57

percent of the wells, artesian pressure brings the water to an elevation higher than the ground surface.

Table 3.4 lists the flow of selected major springs from the principal artesian aquifer and indicates the minimum sustained flow. Figure 3.35 shows the locations of the springs listed in Table 3.4.

The pumping of water from the ground reduces the depth or pressure of the water near the well. The map of Figure 3.36 illustrates this effect for the principal artesian aquifer for the Southeast River Basins. The lines on this map define the piezometric surface, the height above sea level to which water would rise in wells. Where this surface is above the ground level, wells flow without pumping. The data on this map were generalized from different studies and from different years so it shows a composite recent picture but does not give a precise pattern that could be used for design, or to show trends in comparison with similar maps of earlier or later years.

There are about 150 observation wells in the Southeast River Basins whose data are published annually in U. S. Geological Survey publications, "Water Levels and Artesian Pressures." About half of these records started within a year or so of 1940 and most of the rest more recently.

Sustained Yield of Ground Water

The present withdrawal of ground water in the Southeast River Basins is a little less than 1 billion gallons per day. This is equivalent to about one-fourth inch average depth per year over the entire Southeast River Basins area. Projected needs for well water by the year 2000 amount to somewhere between 2 and 3 billion gallons per day. This is less than an inch average depth over the Southeast River Basins each year. Some of it would be returned after use to the surface water supply. A question to be considered is whether this rate of withdrawal could be sustained indefinitely. The answer, based on a recent special study of available meager data, a review of the literature, and some rough computations is that this much and more could be withdrawn safely. According to the study, as reported by the U. S. Geological Survey in a report prepared for the U. S. Study Commission, "The Yield of Sedimentary Aquifers of the Coastal Plain, Southeast River Basins," a sustained yield of 24 billion gallons per day could be taken from the ground without depleting the source faster than it can flow to the wells or be replenished by rainfall. This sustained yield is about 10 times the estimated needs for the year 2000. By reuse and artificial recharge of ground water, the possible availability could be increased far beyond the 24 billion gallons given above. Also, for isolated periods of a year or two, withdrawal rates much higher than the sustainable average would be possible. Excessive ground water withdrawals would create local problems, including diminished availability of certain surface supplies, and would necessitate deeper wells in some areas where steeper gradients would be required in order to sustain the high yields.

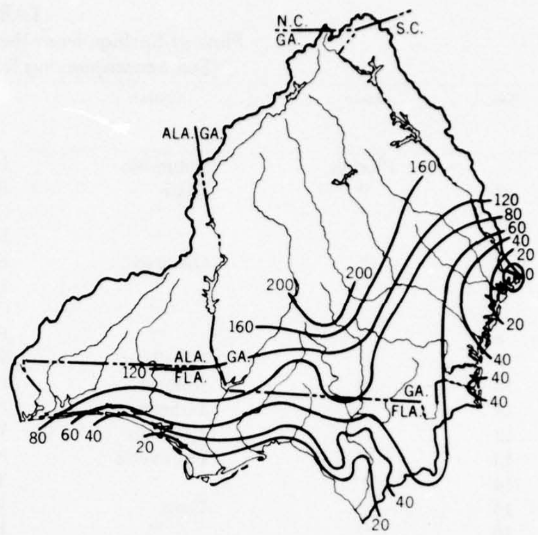


Figure 3.36 *Generalized Piezometric Surface of Principal Artesian Aquifer (feet above mean sea level).*

SECTION VIII – PRESENT STORAGE AND REGULATION

In order to assess the need for future development, it is necessary to know not only the resource potential, but also the present degree of development. For example, it is helpful to know the present water area for recreation and fishing and the present amount of storage and regulation.

Table 3.5 gives the area of water bodies, in thousands of acres, in certain categories, as of 1960.

The total number of farm ponds in 1960 is estimated to be 33,000 with an average size of 3.4 acres. The projected numbers for 1975 and 2000 are 55,000 and 90,000, respectively.

Table 3.6 gives storage data for selected reservoirs as of 1960. Regulation is given both at the damsite and at the mouth of the river because the effectiveness of storage differs with distance downstream from the dam.

TABLE 3.5

Water Areas in the Southeast River Basins (thousands of acres)

Basin number	Selected reservoirs*	Farm ponds	Water area: Total	Water area: Percent of basin area
1	127	11	212.5	3.1
2	0	11	90.9	2.6
3	20	28	116.5	1.2
4	0	8	85.1	2.4
5	0	14	103.0	1.5
6	7	6	106.2	2.6
7	133	24	253.5	2.0
8	0	10	380.2	4.0
Total	287	112	1347.9	2.4 (avg.)

* See Table 3.6.

TABLE 3.6

Storage Data for Selected Reservoirs

Basin number	Reservoir	Stream	Usable storage* (1,000 acre-feet)	Surface area top of power pool (1,000 acres)	Regulation in percent of mean annual flow: At site	Regulation in percent of mean annual flow: At stream mouth
1	Hartwell	Savannah	1,400	57	45	17
1	Clark Hill	Savannah	1,700	70	25	21
2	None					
3	Sinclair	Oconee	214	15	9	1.8
3	Jackson Lake (Lloyd Shoals Dam)	Ocmulgee	76	5	5	0.5
4	None					
5	None					
6	Lake Talquin	Ochlockonee	70	7	6	2
7	Lake Lanier (Buford Dam)	Chattahoochee	1,040	38	69	4
7	Bartletts Ferry	Chattahoochee	133	6	3.0	0.7
7	Walter F. George (Ft. Gaines Lock and Dam)	Chattahoochee	210	45	3	1.3
7	Jim Woodruff (Lake Seminole)	Chattahoochee and Flint	360	37	2.2	2.0
7	Lake Blackshear (Crisp County Dam)	Flint	34	7	1.0	0.2
8	None					

* Does not include volume below minimum drawdown nor space reserved for flood control.

PART FOUR – TRENDS AND TECHNOLOGICAL DEVELOPMENTS

SECTION I – INTRODUCTION

In the plans for projects and programs involving use and management of water, it was assumed that there would be no unplanned change in the regime of water availability by the year 2000. This assumption was based on deliberate consideration of natural trends and of possible technological developments which could affect the supply of water.

A natural trend in rainfall would make irrigation more valuable or less valuable than at present, according to the direction of the trend. Floods might become more severe in the future—or less so. A trend in air temperature would affect evapotranspiration losses and the type of crops or livestock to be grown.

Weather modification must be distinguished from weather control, but consideration of either leads to the possibility of reducing the variability of rainfall and lessening the need to store excess streamflows or to provide water during drouths. If the cost of desalting sea water should become competitive with the cost of other sources of water, including treatment and reuse of waste water, profound changes would result in the approach to water resources planning.

There is evidence that water supply can be conserved by suppression of evaporation from reservoirs and that the streamflow regime is affected by land management practices—both as to floods and as to low flows. In projecting a plan to the year 2000, it is necessary to consider the foregoing influences on the availability of water.

The projected increase in agricultural production will come from combining many activities, including greater use of pesticides and fertilizer. It is necessary to consider what effect this use will have on ecology and water quality.

Short of physical control of rainfall, improved forecasting would have important effects on the use of water. Perfect streamflow forecasting would greatly diminish the required magnitude of storage for flood control. Quantitative rainfall forecasting would eliminate the waste of water and damage to crops in inadvertently irrigating on the day before a heavy rain. Some consideration must be given to trends in forecasting that can be expected by the year 2000.

SECTION II – NATURAL TRENDS

Temperature

Evidence of many kinds supports the growing opinion that there is a long term trend in air temperature. This trend, which has been a slight increase, mostly in wintertime, is evident in the century long records of thermometers at benchmark stations—stations with minimum change in their exposure to the heat of growing cities or to other nonclimatic influences. Glaciers are receding generally; flora and fauna are migrating north of their usual limits.

It is supposed by some that portions of the northern hemisphere are still emerging from the last ice age. It is possible that the sun is a long-period variable star. Studies of these and other theories are not conclusive. There is no indication whether the past trend is part of a long cycle which may reverse at any time or whether it can safely be extended to the year 2000.

Recent evidence indicates that, while for the past century the trend has been up a degree or so, the trend of the past 20 years at some stations has been downward a fraction of a degree.

Inasmuch as both trends are very slight, and there is no way of predicting a future course, no account of a temperature trend has been taken in planning future action in conserving and developing land and water resources.

Rainfall

Rainfall is much more variable than temperature, and a long trend is difficult to discern. There has been indication of a downward trend in rainfall over the past century. There are supporting data and many plausible theories but none of them are conclusive. There is no way of knowing whether the trend will continue or change. Examination of the diagrams on Figure 2.3 may suggest trends in annual rainfall.

Inasmuch as these trends are very slight compared with the great year-to-year variation, and there is no satisfactory way of projecting their course, the best estimate of future rainfall is a continuation of the historical regime.

Streamflow

As a consequence of the downward trend in rainfall and the upward trend in temperature, which would increase evaporation and transpiration, a downward trend in natural streamflow might be expected. Very few records of streamflow are long enough to show a long trend of any kind, particularly with the very great year-to-year variation which tends to obscure a long trend. The variability is so great and most periods of record so short that considerable study, including correlation with rainfall and with data from long record streamflow stations, would be required before a satisfactory mean or trend can be established.

The usual occurrence of ample water in most of the study area has made it unnecessary to determine precisely the average supply of water. Inasmuch as any trend is probably slight, and reversible without prediction, the streamflow regime for the period ending in the year 2000 is regarded as being the same as the historical regime, subject only to artificial regulation such as by storage and withdrawal.

Sea Level

There has been a well-defined and widely accepted upward trend in sea level of about an inch in 10 years. How much of this comes from melting of large ice caps, subsidence of continents, or even change in storage of ground water and surface water is problematical. Inasmuch as the trend appears to be small, unpredictable and perhaps reversible, it has been ignored in planning to the year 2000. The effect of this slight change in average sea level on navigation, use of tidal lands, etc., is trivial when compared with the uncertainties in the height of storm tides, 15 or 20 feet, caused by wind and pressure associated with hurricanes.

Ground Water

The trend in ground water stage and artesian pressure has been downward in much of the study area such as in the vicinity of Savannah and Brunswick, Georgia, and Fernandina, Florida, largely and possibly entirely because of withdrawals through wells. To separate and evaluate natural trends in ground water stage and artesian pressures and to project these trends from increased pumping would require more study than it was expedient to make.

SECTION III – ARTIFICIAL AUGMENTATION OF WATER SUPPLY

Weather Modification

There is no question but that weather can be modified artificially, whether it be condensation trails from aircraft, higher temperatures in big cities than in surrounding countryside, or orchard heating. Studies of cloud seeding show that in the West, with proper conditions and with the help of the mountains, results have been obtained which would be extremely unlikely by chance. In the East, where there is usually plenty of rain, only a little seeding has been done and conclusive evidence of increasing rainfall is lacking. However, experimental research in this field is being undertaken.

Modifying the weather is vastly different from controlling it. It is difficult to forecast the conditions necessary for successful seeding, to avoid under or over seeding and to assess the effects of missing the target area. An error in attempted weather modification could seriously affect the cutting of hay or conceivably worsen a flood.

Because of uncertainty as to the degree of control possible in the East, and the fact that surer methods—such as storing water from wet periods, or pumping it from the ground—are

feasible and relatively economical, the U. S. Study Commission plan for the Southeast River Basins disregards any possible effect of weather modification.

Desalting of Sea Water

Recent experiments have shown the physical possibility of large scale desalting of sea water. Cost studies, however, have shown that such water is more expensive than pumping water from wells or taking it from reservoirs or regulated rivers in regions of ample supply. Such practical problems as pumping the water from the sea to other points of use, what to do with the minerals to prevent scale, and how to dispose of concentrated saline waste, persist. It is anticipated that desalting of sea water will not be economical in the period ending in the year 2000 in an area as rich in natural fresh water as the Southeast River Basins. It would probably be easier and more economical to treat and reuse fresh water.

Conclusion

The study area is endowed with both a mild climate and generally plentiful water, and conventional methods of water management are more economical and more practicable than other methods. The Southeast River Basins probably will be one of the last regions in the Nation where unconventional methods of augmenting water supply will be necessary.

SECTION IV – CONSERVATION OF EXISTING SUPPLY

Evaporation Suppression

Recent experiments have shown the physical feasibility of greatly reducing evaporation by means of a thin film of one of the various insoluble kinds of waxy materials, such as hexadecanol. In pans and small ponds, this material is very effective. On large reservoirs, the maintenance of the film against waves and other action is costly, and the results are less effective though they could be economical in regions where water is extremely expensive. While such films have been found harmless to fish and eventual water users, they might restrict recreational and other uses of reservoirs.

With water as plentiful as it is in the Southeast River Basins, it seems unnecessary to plan on resorting to such drastic, uncertain, and costly methods for saving water.

Reuse of Water

Reuse of water involves either recycling in a process, or successive use of the same water by a series of users along a stream. To understand the implications of reuse of water it is necessary to distinguish between withdrawal and consumptive use.

Withdrawal of water merely means taking it from its usual course and implies nothing as to its return to the same course sooner or later, its diversion to another course, or being evaporated or otherwise consumed. Consumptive use of water means its transpiration, evaporation, or incorporation into a product of some sort—the latter usually being negligible in total quantity.

Successive use of water involves questions of quality of water, convenience, and economics. Considerations for recycling include costs of storage in the using system, possible storage upstream, treatment, and proportion of makeup water. In some places in the United States, ground water recharge has been found to be practicable and economical and in a sense may be either reuse or recycling.

Unless water is consumed, its withdrawal merely involves temporary or local restriction in its use for more than one purpose, or the cost and inconvenience of conveying it back to its usual course, or restoring it to its original quality. Recycling usually has little effect on the total consumption and, therefore, is unimportant to the total availability of water. The important process in total availability of water is its consumptive use.

In agriculture, consumptive use is necessary; and the amount of water circulating through growing vegetation is usually several hundred times the amount actually incorporated in the crop.

As has been shown in Part Three of this Appendix, there is plenty of water on the average.

The only problem is its distribution in time and place. As shown in the basin appendixes there is competition for water in only a few areas. In order to tide over low periods it is necessary to store water for some uses, but in general there seems to be little need to consider scheduling for joint, successive, or alternate use of the same water. Accordingly, a study of recycling and reuse has been unimportant to the planning of use of water. No study has been made of artificial ground water recharge in the Southeast River Basins.

Phreatophytes

Vegetation is the main user of water—in the sense of consuming it, rather than delaying or dispersing its availability for other uses. Phreatophytes are deep rooted plants that withdraw water from the water table or from the soil just above it. In arid regions they reduce the flow of streams to a degree which has led to eradication campaigns. In the Southeast River Basins the problems along vegetation-lined streams are access, quality, and habitat more than quantitative conservation of water.

Reservoir Operations

The manner in which multiple-purpose reservoirs are operated is a factor in water conservation. Good operation promotes efficient water use and prevents waste that is likely to occur with poor operation. Good operation will be particularly important in the Apalachicola-Chattahoochee-Flint basins where a series of reservoirs with locks are utilized in developing the Chattahoochee River for navigation. To insure good operation, a specialized staff of river control engineers is essential to establish daily schedules. The use of electronic computers, a relatively new aid in river forecasting, promises to materially improve reservoir operations and thus conserve water.

Other Methods for Conserving Water

Air-fin cooling, instead of cooling with water, is regarded as a saving of water, but using water for cooling is not necessarily consumptive. Use of saline water for purposes such as cooling is also regarded as saving fresh water, but the reason for using saline water for cooling is usually merely the fact that saline water will do, and frequently happens to be the kind at hand. Because of the usual abundance of water in the Southeast River Basins, a study of these and other water-saving practices did not seem justified and was not made.

SECTION V – CHANGES IN THE HYDROLOGIC REGIME

Introduction

Storage and diversion of surface runoff for any purpose affects the supply of water for other purposes. Pumping and diversion of ground water to streams after use may decrease streamflow in some places and increase it in other places. In soil conservation, efforts are made to retard erosion by land treatment. These and other effects must be considered for coordinating planning.

Land Treatment

Examples of land treatment are changes in land use from row crop to pasture, improved stands of timber, controlled grazing, shift from continuous cropping to rotation, and provision of cover crops. It has been shown that, on small plots and on a number of larger research watersheds, these factors reduce peaks of most floods and, in some cases, influence total runoff.

One factor is that small areas differ significantly from large areas in the movement of subsurface water. The other factor is that over a large area—10 square miles or more—due to the difficulty of controlling land-management practices for evaluation, there may be compensating changes in land use and in cropping practices.

The effects of land treatment measures on large watersheds depend, in part, on the measures being considered. Measures in which storage of runoff is involved are readily evaluated and their effects are recognized in previous studies or reports on flood prevention in large watersheds. Measures in which infiltration is involved are less readily evaluated on a large

watershed. For land treatment measures, a conservative determination of the effects on peak flow was made.

It has been estimated that land treatment over large areas in the Southeast River Basins could reduce flood peaks to an appreciable degree, the effect being greater on lesser floods and least on the largest floods. No assumption or computation has been made as to the effect of land treatment on low flows or total water yield.

Seepage from Reservoirs

Whenever a reservoir is built, in the Southeast River Basins or elsewhere, it is necessary for the design to consider problems of seepage and leakage under the geologic conditions existing at the particular site. Otherwise, losses through or around the dam or into the ground beneath the reservoir might significantly diminish the quantity of water stored for planned uses. Such seepage or leakage may be undesirable from the standpoint of safety of the dam. Apart from project considerations, such seepage does not necessarily represent an ultimate water loss, being merely a transfer from surface waters to the underground where, conceivably, it could contribute to aquifers which are sources of pumped water.

When a reservoir is impounded, there is a rise in the water table surrounding the shoreline and an initial loss from bank storage which is not recoverable unless the reservoir should be drained. The higher water table may result in problems of subsoil saturation requiring drainage, of higher levels and alleged pollution in domestic wells around the reservoir, and sometimes of responsibility for creating new sink holes.

If the design fails to guard against seepage or leakage under or around a dam, there may be a rise in the downstream water table with consequent drainage problems.

It is not anticipated that any of these seepage and leakage problems will be significant in the study area, it being assumed that agencies implementing the Commission plan will make necessary provisions in design and construction of any structures to prevent seepage losses. This being the case, it has been unnecessary in the planning of projects to evaluate or allow quantitatively for seepage losses.

Net Reservoir Evaporation Loss

In addition to the purpose of a reservoir to regulate streamflow or to constitute a water body, it may have the effect of changing the total yield of water from its drainage area. The difference in yield may come largely from the difference between evaporation from the reservoir water surface and evapotranspiration from the corresponding land surface previous to construction of the reservoir.

Ignoring boundary effects, there is a net estimated loss from most reservoirs ranging from zero to 10 inches average depth per year. Boundary effects, particularly with hydroelectric drawdown, tend to reduce the net loss because the evaporation from the exposed land around the reservoir perimeter is less than from the water surface. In some instances, the net effect may possibly be an accretion instead of a loss.

In planning a few of the reservoirs, account was taken of estimated net reservoir evaporation for dry years. For estimating drawdown or reservoir yield in extremely dry conditions, such as recurrence of the 1954-56 drouth, evaporation 30 percent higher than average was assumed, along with observed or interpolated 1954-56 rainfall and runoff.

No account was taken of the effect on total water yield of net evaporation loss from the aggregate planned and projected surface area of reservoirs. Because the total projected new water area is a small fraction of the entire study area, the net loss may be within the error of estimating the water yield itself from the study area.

Ground Water – Surface Water Interchange

In the Coastal Plain province, much of the water taken from the ground is discharged after use into streams, thus adding an artificial increment to streamflow. In the future, this process will probably increase. On the other side of the ledger, heavy pumping near streams will reduce streamflow; and where reservoir seepage occurs, there will be an artificial increment of surface water added to the ground water. There are some indications that seepage and recharge are occurring in the vicinity of Lake Seminole on the Chattahoochee and Flint Rivers above Jim Woodruff Dam. A lesser effect which can be

cited is the withdrawal of surface water for use in fairly large areas served by septic tanks—with an accretion to ground water from the field lines. All these and other such effects are believed to be relatively small in the aggregate and have not been evaluated.

Irrigation Loss

In the Southeast River Basins, the projected irrigation program is not large and is considered to have only slight local effects on streamflow or ground water. Most irrigation will probably be sprinkler type with very little return flow.

Urbanization and Highways

Important local effects can be expected in a few instances of interbasin diversion where ridge cities take water from one stream and discharge it as effluent into a different stream. The development of highways and urban areas tends to change the hydrologic balance by increasing impermeable areas, and storm sewers and roads may change the time of concentration as compared with natural surface drainage. In the few places of appreciable size where the effect of urbanization has been investigated, the influence of roofs, concrete and lawns as compared with pasture, cultivated fields and woods, has been found to be too small for measurement. Possibly compensating influences are involved.

While some urban subdivisions may seem large, the aggregate area of impervious cover in urban areas and highways is and will continue to be a very small percent of the total Southeast River Basins drainage area. Unless an impervious area has a very large contiguous expanse, the water falling on it can enter the soil nearby and percolate laterally into the soil underlying the impervious area. Much of the rain from roofs soaks into nearby lawns. It is believed that the ultimate effect of urbanization including lawn watering can easily be exaggerated, is relatively small in the aggregate, and except very locally has little influence on the hydrologic balance.

Water Use in Pipeline Slurries

The transport of coal and other material by slurry and pipelines has proven feasible in recent years under appropriate conditions. Transportation of coal into the Southeast River Basins by slurry would bring water into the study area, but some water would no doubt be evaporated by combustion. For an example of the amount of water involved, if all electrical energy needs of the study area for the year 2000 were supplied by coal brought in by a 2:1 slurry, an estimated 100 cubic feet per second would suffice. Local questions of availability of water might arise, for example, in the movement of kaolin by slurry; but the total movement of such water in the Southeast River Basins would be trivial from the standpoint of general availability and effect on the hydrologic regime.

Conclusion

Consideration of the foregoing and other factors has led to the conclusion that, for the purpose of broad planning for projected conditions in this humid region, these factors can be neglected in comparison with other uncertainties as to the availability of water. Though it is estimated that the total supply of water will be about as at present, there will be a change in the extremes of flow because of storage of water in new projects. This is the purpose of water management. Floods will diminish in frequency and magnitude of flow, and low flows will be less frequent and less severe than would occur naturally. An example of the type of change to expect is shown in Figure 3.27 of Part Three which compares the flow of the Savannah River at Augusta with and without the operation of Clark Hill Reservoir and other upstream storage. Similar diagrams and flood-frequency curves could be prepared for proposed projects, based on various assumed models of operation.

SECTION VI – WATER USE IN ELECTRIC POWER GENERATION

Cooling Water

Thermal generation of electrical energy requires condenser cooling, which uses vast amounts of water. Future development of power by nuclear and other new thermal processes will in all probability require cooling—most likely

by water. The availability of water is not particularly a problem in cooling if thermal plants can be located at tidewater or reservoir sites, depending on what fuel they would use, and the water can be recirculated. The main effect is the local deterioration of water quality through heat pollution resulting from the increased temperature. The higher temperature also increases slightly the evaporation loss from the receiving stream.

Hydroelectric Power

The main use of hydroelectric power in the Southeast River Basins is for supplying energy for brief peak periods. It is relatively uneconomical to keep steam pressure up hour after hour and day after day in order to provide for peak loads during the day and week. With hydroelectric power there is no waste of energy and no delay in opening or closing the valves.

Whether future power is to be generated by coal, oil or gas, or by nuclear or other energy, it is assumed there will still be a need for hydroelectric power for peaking. As with cooling water, while tremendous flow of water through the turbines may be projected, none of it is used up and the effect on the supply of water is merely a local diversion—between the upper end of the penstocks and the tailwater. In shallow reservoirs there will be no impairment in quality. However, if the water is drawn from a deep reservoir, the water discharged will be low in dissolved oxygen and recovery to restore the deficiency will occur only after several miles of open channel flow and reaeration below the dam.

In the event that nuclear or solar energy could be converted economically and directly to electrical energy, without going through the heat phase, then cooling water might be unnecessary and hydroelectric power for peaking might no longer be relatively economical. The plan of development to the year 2000 is predicated on conventional power production.

SECTION VII – WATER QUALITY

Though the total supply of water is more than adequate, merely requiring storage, rescheduling, and diversion, the question of water quality remains. The planned program of prevention and abatement of pollution can help insure continued high biological and chemical quality of water for industries, agriculture, and municipalities.

Continuation and greater application of soil and water conservation measures, the continued building of impoundments, and continuation of the trend in land use from crops to pasture will reduce further the presently low sediment loads of streams in the Southeast River Basins. The process of grading for some urban and highway construction produces transient increases in runoff and sediment load. The urbanization trend may, through interbasin diversion of municipal and process water, change the quality of a few headwater streams. The conversion of cultivated fields to paved areas and lawns will probably diminish sediment load in some areas.

Use of water for cooling will raise the temperature of streams locally. In the case of moderate-sized plants, streams may be expected to assume equilibrium with their environment by heat exchange with the ambient atmosphere radiation balance, and other factors; and the net increase in temperature will be small. However, this may not be the case for the very large thermal powerplants which typify present-day practice. Serious heat pollution can result from such installations in locations where water supply exceeds requirements by only a limited margin.

The deterioration of water supply that has occurred by the intrusion of salt water into coastal aquifers can be eliminated or controlled through vigilance and proper management so no deterioration of ground water in this respect is projected.

A more intensive agriculture will have some effect on water quality. In the Southeast River Basins, there will be very little irrigation in percent of total area; and almost all the irrigation will be sprinkler-type with very little leaching.

The increased use of fertilizer and pesticides will have an effect on water quality. Fertilizer, in general, will have a beneficial effect on the flora and fauna of streams. Occasional over-

growth and subsequent die off could be detrimental. Insecticides and herbicides, on the other hand, may create serious pollution problems in some localities. Presumably methods to reduce erosion will help reduce local runoff of pesticides, but it would be difficult to assess the total large-scale effect. Use of pesticides with rapidly diminishing properties is expected. It is assumed that some way will be found to deal with the problem of detergents and other chemicals which are not now amenable to treatment by biological processes.

SECTION VIII – FORECASTING RAINFALL AND STREAMFLOW

Introduction

If storm rainfall and subsequent flood runoff could be forecast perfectly, and over a period long enough, it would be feasible, in some situations, to utilize for other purposes some reservoir storage space which would otherwise be held in reserve for flood control. However, even though this might be advantageous in some floods, it would not decrease the total flood storage required since that is determined by the design flood for which protection is provided. Perfect or near-perfect forecasts are not now possible, but forecasts that can be made have proven invaluable in the operation of reservoir projects.

Having no forecast, or ignoring a forecast, does not eliminate the problem of how to operate a storage project or other use of a river. In lieu of a forecast, the operating decision is based on an implied assumption of some sort as to future events.

If weather forecasts were to improve greatly, the benefits to outdoor recreation, including hunting and fishing, would be much more secure and more definitely assured. Forecasts of streamflow in the Ohio River are now used in coordinating pollution abatement measures with changes in expected flow.

There are instances where reservoir operations have made floods worse than they would be without the reservoir. To assure against this in the Tennessee Valley, there has been a program of routinely estimating what the flows would have been in the absence of the reservoirs.

Rainfall Forecasting

The factors used in forecasting weather are so changeable that forecasts beyond 1 or 2 days rarely have much advantage over the assumption that the weather will be about normal for that time of the year. The forecast of rain or no rain one day in advance is right about 80 percent of the time in most places. Recent improvement in forecasting service has come largely from better regional coverage, better pinpointing, more frequent forecasts so as to keep up with rapidly changing conditions, and better dissemination of forecasts.

The chances of long-range forecasting becoming dependably accurate seem now to be remote. Satellites and radar and other recent technical developments give greatly improved surveillance but, as yet, very little assurance of methods for seeing further ahead. Electronic computers now plot weather maps and are able to do part of the job a little better and considerably faster than the manual methods. This gain of an hour or two, in effect, extends the forecast range an hour or two.

In the present status of forecasting rainfall, most forecasters usually indicate merely whether rain is expected or not. However, research in quantitative precipitation forecasting has progressed to a degree which enables the Weather Bureau to render effective assistance to reservoir operation on the Chattahoochee, Savannah, and other rivers. Continuation of this research holds much promise. Another advance in forecasting techniques is that of probability forecasts. These, too, have shown some promise. The probability forecast is not a sophisticated way of introducing vagueness into the forecast but is a quantitative means for indicating the degree of uncertainty which nearly always attends a forecast. For example, for some operational decisions it would be helpful to know whether the predicted rain had a 70-percent chance of occurring versus a 30-percent chance of occurring.

We can expect over the next 30 to 40 years that the trend of better surveillance, more frequent forecasts, and better dissemination will

continue. We can expect a trend toward better statements of probability and improvement and wider use of quantitative forecasts. These are benefits to any program involving outdoor activity. A breakthrough in quantitative rainfall forecasting would obviously have a tremendous beneficial effect on all water-related aspects of the U. S. Study Commission program, but it is not assumed that this is imminent.

Streamflow Forecasting

Until about 20 years ago, streamflow forecasting was little more than predicting the rate of movement and future configuration of flood waves that had already formed and were moving down from the headwaters of a river. Now flood forecasts are made soon after the rain starts to fall, and many hours are added to the forecast interval.

In order to make a forecast timely, methods are used to obtain an optimum balance between speed and accuracy. With the advent of electronic computers, it is now possible to have both high speed and a high degree of accuracy. Recent experience with water-accounting methods shows definite gains that should become evident in a very few years. How fast these gains will be recognized and applied will depend more on institutional factors than on the state of the art. When these prospective gains are combined with improved and effective use of quantitative rainfall forecasts, the influence on river regulation could be tremendous.

Future streamflow forecasts will cover a much broader scope than forecasts of flood stage. Future forecasts will pertain to the entire hydrograph, as far in advance as it will have any merit – certainly several days and possibly weeks or months – and will include probability statements. This program will be helpful for many purposes. In the Tennessee Valley this type of forecasting has been in successful use for some 25 years. A daily bulletin issued jointly by the Tennessee Valley Authority and the U. S. Weather Bureau disseminates the information to the public. Recreation and fishing interests as well as project operators make use of these forecasts.

The implications of improved streamflow forecasts on the benefits of water management programs have not been examined in this study, but they could be significant.

PART FIVE – METHODS AND CRITERIA

SECTION I – PROCEDURAL STEPS

The steps to be followed in formulating a plan for water resources development are essentially as follows:

1. Evaluate the existing water regime in terms of drainage pattern, water areas, stream profiles, storage and diversions, frequencies and extremes of high and low flows, seasonal variation, draft-storage curves, flow-duration curves, and rating curves; and depth and yield of aquifers.

2. For each use or abatement, determine the functional relationship between the degree to which the water regime may be modified and the amount of resulting benefits for each purpose; stage-damage-frequency curves, area-benefit curves, dollars per acre-foot, etc.

3. For each purpose, determine the approximate future need for use or abatement; population and per capita rates, acres affected and per-acre rates, etc. with frequency and magnitude criteria.

4. For each area of use or abatement within a basin, compare the future requirements with the availability of water in its existing and expected future regime.

5. Establish the approximate magnitude and location of storage, diversion, and other measures for a preliminary plan to meet the expected requirements for key future dates; adding the needs and space requirements considering joint, alternative, and successive use of water and storage space, seasonal variation in flow and needs, using local water budgets.

6. Evaluate the changed water regime of the preliminary plan and determine its physical feasibility using a drainage area water-accounting system based on a historical or synthetic record covering periods of high and low flows.

7. Modify the preliminary plan so as to maximize the net benefits or minimize the cost, using the functional relationships of step 2 to adjust competing uses of water, considering seasonal and frequency distribution of need for water, alternate sources of water, alternate places of use, and alternatives to the use of water.

8. Examine and accommodate side effects such as weekend holdover in hydroelectric generation, return flow from dispersed withdrawals, reservoir evaporation, pumping for leveed local drainage, consumptive use, etc.

9. Reevaluate the modified water regime, making sure of its physical feasibility, going through successive stages of approximation converging toward optimum development with optimum distribution of water use among purposes, and with proper scale of development.

10. Make final regional adjustment on the basis of interbasin optimization.

In general, the foregoing steps were followed largely qualitatively and only approximately. Constraints included the need to work with only knowledge and methods available at the beginning of the study or which it was thought at the outset could be completed in time, the requirement of estimating only for places where potential development is expected, heterogeneous agency criteria, limited time and data, limited precision of functional relationships, limited precision of projected needs, the need to avoid excessive departures from existing agency methods, and the lack of regional generalizations. Accordingly, a high degree of detail and refinement seemed unwarranted.

Other factors entering the decision making process include the operation of social, institutional, and other more or less intangible influences, and the degree of judgment required which may be great where the best analytical method is not clearly ascertained. In some instances, these intangible and subjective factors outweighed the conclusions reached or even possible by objective analysis.

A major portion of each single-purpose study was accomplished by Federal, State, and other authorities through agreement and transfer of funds. This work was done according to specifications contained in a technical supplement for each purpose developed by the U. S. Study Commission staff. These specifications provided for

scope, degree of detail, definitions, and assumptions and are discussed in the respective portions of Appendix 12, Planning.

These single-purpose alternatives were adjusted and combined by the general procedure outlined earlier in this Section. Some of this process of combining single-purpose alternatives into multiple-purpose plans was done by Federal agencies through agreement and transfer of funds for terminal studies according to Study Commission specifications. Most of the process was done by staff members, basin by basin.

SECTION II – METHODS FOR SINGLE-PURPOSE FACILITIES

Flood Control and Prevention

For prevention and control of floods, the work was divided largely on the basis of size of drainage area. Studies were made under agreement with the Commission by the Soil Conservation Service, U. S. Department of Agriculture, for headwater areas, and by the Corps of Engineers, Department of Army, for main stems or major rivers. In general, the distinction between large and small areas, separating the work of the two agencies, came at drainage areas ranging to about 1,000 square miles. The specific division into the two agency categories is shown on a map included in the working papers of the Commission, but not reproduced here, which shows the exact areas of responsibility agreed to by the Soil Conservation Service, Corps of Engineers, and the U. S. Study Commission.

A very important fact about planning for small watersheds is the large number of them in the 88,000-square-mile expanse of the Southeast River Basins area, and the practical impossibility of dealing with them individually in this study. Another important fact, shown in Table 3.1, is the small amount of observed streamflow data for small watersheds in this region.

For small watersheds a generalized approach was used, based on analysis of more than 150 detention structures in 20 planned upstream watershed projects in the Blue Ridge and Piedmont physiographic provinces in and near the Southeast River Basins area, plus 10 watersheds in the Coastal Plain province selected specially for field study for development of data for generalized planning. These 10 sample watersheds were selected by experienced agricultural people, both local and U. S. Department of Agriculture. Selections of the areas were made on the basis of land use, types of flood damage, topography, soil type, and other existing conditions. The Public Law 566 type sample watershed detention structures had drainage areas from less than 1 square mile to about 15 square miles, three-fourths of them being less than 5 square miles.

Hydrologic methods are involved in two places in this sampling procedure. One place is in the methods employed in the sample watersheds, and the other place is in the hydrologic relationships inherent in the application of conclusions from the sample watersheds to the other watersheds.

Hydrologic methods and criteria employed in the sample watersheds are described in the U. S. Soil Conservation Service Engineering Handbook, Hydrology Supplement A. By those methods a series of annual floods is synthesized by generalized treatment of rainfall and watershed characteristics, in which consideration is given to antecedent moisture condition of the soil, soil type, and type and quality of vegetative cover. Antecedent moisture condition is given by one of six categories, made up of three classes of 5-day antecedent rainfall, and two classes of season, dormant and growing season. The influence of soil type is given by selection of one of four large categories into which all soils have been classified.

Hydrologic effects of land use and treatment are expressed by identifying the observed or expected conditions in a table which gives for each of the four hydrologic soil groups a curve number for a variety of land use, treatment, and hydrologic condition. Hydrologic condition is given by adjective categories such as poor, fair, and good.

Large watersheds have a variety of cover, soil type, and condition; so an average curve number for the entire watershed is obtained by determining the curve number for each incremental area, and weighing these by size of area in proportion to total drainage area.

In transposing sample area data to prototype watersheds several methods were used. One

method was the direct transfer of data or relationships from a sample watershed to a watershed which was regarded as similar. Another method was the taking of pertinent data from generalized curves with interpolation on the basis of observed or estimated differences in land use, size of drainage area, and similar information. A Soil Conservation Service guide which was used in this study is that where as much as 4 percent of a planning unit watershed was in the bottom land category, development of storage for flood prevention was usually warranted. In some instances, particularly in the Coastal Plain, the only improvement planned was channel work.

In transposing hydrologic relationships from one watershed to another, two considerations are necessary. One is the degree to which physical relationships, such as rainfall to runoff, are expressed by the parameters used in the transposition. Such parameters are land use, soil type, topography, and rainfall regime. The other consideration is the effects of scale. The treatment of data from small watersheds tends to emphasize direct runoff and minimize ground water influences which are often trivial in magnitude with respect to direct runoff. With larger watersheds a greater proportion of runoff is delayed in passing through the soil on its way to the point of measurement.

A typical annual flood series was obtained by applying the procedures described briefly above to a historical series of large rainfalls over a recent 20-year period. Consideration was given to time of year of occurrence of flooding. Peak flows were determined by unit hydrograph and storage routing, with and without watershed treatment and detention reservoirs.

In general, a small reduction in flood peaks was postulated for future land use conditions as compared with present conditions. This reduction would reduce present average annual flood damage 12 percent in each planned watershed.

For flood detention the volume of storage, from the top of the drop inlet to the level of the emergency spillway, was generally determined on the basis of a 25-year flood, which was generally about 5.0 inches of runoff for a hydrograph base of 48 hours. For spillway design for small watershed dams, a full pool is assumed, and a 6-hour storm producing 9.25 inches of runoff was the usual criterion.

For large drainage areas, the Corps of Engineers estimated flood frequency characteristics for flood-damage sites or reaches by preparing flood frequency curves from recent floods which covered a good range of magnitude, or in some instances from an array of synthetic floods which cover a range of frequency. For areas with small watershed projects, hydrographs from the smaller watersheds were taken as given by the Soil Conservation Service, and routed by storage methods downstream.

Average annual flood damages for large drainage areas were estimated by combining stage-discharge, discharge-frequency, and stage-damage curves to obtain damage-frequency curves, and then integrating the area under the curves. This procedure, applied usually to urban damage centers, gives results different from taking the average annual flood damage, as is done with upstream agricultural damage. Justification for employing the different procedures is that extreme floods produce a major portion of the urban damage, and agricultural damage is largely from the repetition of lesser floods. The two methods reflect this distinction.

In determining flood-frequency relationships, the log-normal method was generally used, with recognition of skew as a variable. The differences between the results of this method and of other methods such as Gumbel, are not great in the present context, where the purpose does not warrant high precision, and where the data themselves do not lend precision.

Channel improvement could be classed as either flood prevention or drainage, according to two criteria. If the channel improvement were independent of storage, and if the design capacity corresponded to a flood of 2 years or smaller return period, it was regarded as drainage. If the channel work were associated with storage, a portion of it was related to drainage on the basis of relationship of two areas requiring project action; one area having a drainage problem, and the other area having a flood prevention problem.

Channel capacity downstream from a work of improvement is an important factor, and the discharge capacity of the drop-inlet spillways in the Public Law 566 type structures range from about 10 to 100 cubic feet per second per square mile, depending upon local conditions and increments of standard size conduits.

Water Supply and Pollution Abatement

Projections of water needs for municipal, industrial, and individual proposes and for assimilating polluted effluents were made on the basis of extrapolating historical trends in number and size of users and in unit rates. For municipal use, for example, the population and per capita consumption were projected.

Flowing water not only carries wastes but dilutes and stabilizes them chemically and biologically. The amount of dilution water required for pollution abatement was estimated on the basis of seven parts per million of dissolved oxygen in the receiving water, the biochemical oxygen demand of the effluent after primary, secondary, or tertiary treatment, and maintaining a minimum for the mixture of four parts per million of dissolved oxygen.

The criterion of design frequency and duration for surface supplies and for pollution abatement was taken to be the consecutive day minimum flow occurring on an average of once in 10 years. These flows were estimated from a generalized approach, based on a 61-station sample of long-record stations in the Southeast River Basins area. The storage requirements were averaged for three or four seasons, shown by a graphical frequency study to have about a 10-year return period.

For ground water, the only criteria for water supply sources were generalized designation of areas known to have certain characteristics. In the Piedmont and Blue Ridge provinces, the ground water is generally good, but wells there have small yield. A band about 40 miles wide south of the Fall Line has high yields in some places and low yields in others. A band about 40 miles wide along the coast has plenty of ground water and high yields, but near known centers of heavy pumping, salt-water intrusion is already or soon may be a limiting factor. At a few places near the coast, there is excessive mineral content. The rest of the Southeast River Basins area generally has plenty of excellent ground water, much of it requiring little treatment for any use.

Surface water withdrawn for industries, cities, and individual users generally returns to the same stream from which it was withdrawn, with slight consumptive use. Return flow of ground water, after its use, augments streamflow slightly. Except in a large ridge city, such as Atlanta, where water may be taken from one basin and allowed to flow into another, the effects of water use on quantity of flow may be neglected. In the Atlanta metropolitan area about 45 cubic feet per second taken from the Chattahoochee is discharged to tributaries of the Ocmulgee River.

Navigation

Improvements for navigation include harbors, canals such as the Intracoastal Waterway, and streams which may be developed for either slack-water or open-river navigation.

No important hydrologic criteria or methods have been involved in planning harbor or level canal navigation by the Study Commission.

Just as highway lanes and railroad gages have been standardized, the minimum depth for commercial navigation has been standardized usually at 9 or 12 feet. Barges with small draft tend to be uneconomical for most commercial traffic.

To maintain a minimum depth of 9 feet in a typical Coastal Plain river requires a flow of a few thousand cubic feet per second, and perhaps too often excessive velocities would occur, making upriver travel slow and uneconomical. Generally, a velocity of less than 6 feet per second at ordinary river stage is desirable. With slack water, vessels move from pool to pool through locks whose operation usually requires much less water than for open-river navigation.

For open-river navigation the costs for reservoir storage and channel maintenance tend to be high and for slack water the locks and dams are major costs. Decisions are based largely on standard hydraulics, engineering, and economics, as described in the Corps of Engineers manuals. The hydrology involved is little more than developing and applying draft-storage relationships, as described in Part Three of this Appendix.

Irrigation

Methods and criteria for planning irrigation are based largely on adaptations of Irrigation Handbooks for the States of Alabama, Florida, Georgia, and South Carolina published by the U. S. Soil Conservation Service; and Section 15 of the Soil Conservation Service Engineering Handbook. Some average cost data were supplied by the U. S. Agricultural Research Service. De-

termination of future irrigated acreage and of water needs for irrigation was a product of judgment as to economic returns from irrigation covering the operations and maintenance costs of irrigating certain crops and soils, and was extrapolated from recent short trends.

Supplemental irrigation practices in this region, based on judgment and experience, use the criterion of a 5-year return period, a 20-percent chance. For convenience in generalizing, the average annual depth of irrigation water was about 8 inches, without regarding this value as a standard or criterion.

In general it was assumed that much of the water for irrigation above the Fall Line would come from farm ponds, and below the Fall Line, particularly in the Lower Coastal Plain, would come from pit wells and streams, relying on generally known local availability of water without making site studies.

The sources of ground water used for irrigation are too dispersed and the volume of water used is regarded as too small in amount to limit the general availability of ground water for other purposes. In storing surface water to supply irrigation needs, generalized draft-storage curves were occasionally used, as illustrated in Part Three of this Appendix. Where irrigation was one of several purposes for storing water, it was assumed that all the needs for water would peak at the same time. This, in effect, amounted to a more severe criterion than one year in five, and in some cases more severe than the probability inherent in the draft-storage curves.

Drainage

Methods and criteria for drainage were based largely on adaptations of the U. S. Soil Conservation Service Drainage Handbook and Section 16 of the Soil Conservation Service Engineering Handbook. In adapting these standards to the Southeast River Basins area, a watershed sampling method, as described in the Flood Control and Prevention Section of this Appendix, was used.

In assessing the need for drainage, reference was made to the land classification reported in the U. S. Department of Agriculture Conservation Needs Inventory, which, in addition to classifying land into eight capability classes, designated certain areas as wet. This classification was made on the basis of a 2 percent to 4 percent sample of the total land area. For land to be classed as wet, soil surveyors considered the lay of the land, soil profile, and existing drainage situation.

Of the total wetland, only a small portion is expected to be drained by the year 2000. The amount of land to be drained was projected on the basis of institutional as well as economic and physical factors. The interpretation of physical factors was the overall judgment on the part of experienced authorities, both local and U. S. Department of Agriculture. A reason for projecting the amount of land to be drained, instead of basing it on economic and hydrologic site studies, is that land drainage is largely a matter of private initiative, and decisions would not necessarily be based on objective analysis of physical and other data.

Land Capability Classes and land use formed the basis for determining the degree of protection to be provided in the channel design. Channel capacity was determined by the formula $Q=kM^{5/6}$, where Q is the channel capacity in cubic feet per second, M is the drainage area in square miles, and k is a factor related to land use.

TABLE 5.1

Values of k – Drainage Channel Capacity Coefficient

Basin and State	Land use			
	Crop-land	Pas-ture	Range	Wood-land
Savannah, Georgia	58	34	—	15
Ogeechee, Georgia	58	34	—	15
Altamaha, Georgia	58	34	—	15
Satilla-St. Marys, Georgia	—	—	—	15
Satilla-St. Marys, Florida	45	25	20	10
Suwannee, Georgia	58	34	—	15
Suwannee, Florida	45	25	20	10
Ochlockonee, Georgia	58	34	—	15
Ochlockonee, Florida	45	25	20	10
Apalachicola-Chattahoochee-Flint, Georgia	58	34	—	15
Choctawhatchee-Perdido, Florida	45	25	20	10

Channel grades, side slopes, widths, and depths follow standard hydraulic design practices as described in the U. S. Soil Conservation Service

Engineering Handbook. Manning's "n" was generalized from handbook tables and judgment as to local conditions. Care was taken to assure adequate channel capacity downstream, with an estimated return period of 2 years as a criterion.

Improved drainage would theoretically affect the hydrologic regime by changing soil moisture, riparian vegetation, ground water stage, runoff, and time of concentration of drained areas. No study was made to estimate these influences which are presumed to be negligible except very locally. The effect of drainage on flows and availability of water over the Southeast River Basins has been taken to be nil.

Hydroelectric Power and Industrial Development

Industrial development is projected on the basis of population, resources, and economics. The important hydrologic aspect of industrial development in the U. S. Study Commission plan is assurance of plenty of good quality water, requiring only development and management.

For hydroelectric power generation, monetary values have been put on projected needs for capacity and energy. Alternative sites, heads, and schedules of operation were considered and objective computations made of costs and benefits. Consideration of alternatives and optimum scale of development was carried only far enough to demonstrate physical feasibility, provide a basis for assessing economic feasibility, and give general magnitude of development.

Hydrologic methods included interpolation and extrapolation of flows at ungaged sites and simple reservoir water budgets.

Fish and Wildlife

Preservation, protection, and enhancement of fish and wildlife resources have been expressed for water-oriented management largely in terms of improving the environment for fish, waterfowl and other game. The physical measure of improvement is annual user-days of hunting and fishing. The improvement insofar as water regulation is concerned is an impoundment to: (1) Regulate flow; (2) provide additional area of water surface; (3) provide desired salinity; and (4) maintain quality of low flows.

Water quality is expressed in terms of maintaining dissolved oxygen at a level of at least four parts per million and eliminating toxic concentrations of toxic waste.

Regulation of flow for fishing consists largely of maintaining minimum flows for the period May through October within the limits of about 25 percent to 75 percent of average annual flow, when available, and allowing natural flooding the rest of the year. For waterfowl, the low-flow period ends earlier, with desirable bottom land flooding starting about the first of October. Exactly where, within and occasionally beyond the limits of 25 percent to 75 percent of average flow, the average flow is to be maintained was largely a matter of judgment. Judgment also determined the frequency criterion to be the 10-year return period, or 10-percent chance, though no relationship was established showing benefits versus degree of regulation for other than the regime judged to be desirable.

The length of reach to be controlled and the size of impoundment to be built depended on fishing load in user-days per mile of stream and per acre of impoundment. Annual user-days of fishing per mile of stream ranged from less than 30 to more than 1,000 depending on width of the stream and how it is to be stocked and managed.

The number of annual user-days of fishing per acre of impoundment ranged from 5 to 300, depending on how the impoundment is to be stocked and managed, proximity to population, and alternative fishing opportunities. Stocking and management factors include species of fish, access, water quality including temperature and nutrients, and other site characteristics. These and other factors were expressed through judgment in terms of area of new impoundment needed and minimum low flows needed for streams.

Recreation

For water-using recreation, in addition to the requirement of sufficiently high standards of quality of the water for water contact sports, the opportunity and the problem are to relate the quantity and nature of the resource to the quantity and nature of the need.

Quantitative factors in measuring water as a recreational resource include area of water surface, distribution of water depth, and rate and

amount of water movement, both horizontally as in a stream and vertically as with a reservoir surface. Additional pertinent physical characteristics of water are its color, turbidity, and temperature. These factors all vary seasonally and in other measurable ways. Measurable environmental factors include shoreline configuration; type of sand, soil or rocky material which comprises the shore; riparian vegetation; and esthetic values which are not easy to measure but which were given consideration in decision making.

Quantitative factors in measuring need for water for recreational use include the number of people expected to engage in various types of activity at various times of year, the space they need for these activities, and characteristics other than space. For some activities the same space can be used jointly or consecutively; combined use by certain other activities would be objectionable.

Because there is no generally recognized methodology for relating recreation needs to objectively defined resource capacities, the Commission sought the advice of experienced experts in the field of recreation. The Commission findings were based on extensive office and field studies, which considered subjectively such factors as size and location of population, personal income, leisure time, esthetics, available land and water resources, current experience, and trends.

Although density was not used as a planning guide, density of use in the study area ranges from less than 4 user-days per acre of water per year in certain wilderness or swamp areas, to more than 4,000 in certain small areas. For recreational boating a criterion was chosen of minimum depth of 3 feet to be maintained 9 years out of 10. In general, decisions relating to the number and scale of development of water resources for recreational use were based only slightly on hydrologic studies.

Sedimentation, Salinity, and Beach Erosion

These purposes involved no significant hydrologic methods or criteria.

Estimates of sedimentation rates were made for reservoir storage on the basis of the limited information available. In general, sedimentation rates of 10 to 100 parts per million are believed to be typical of the Coastal Plain, and up to 10 times that for the steeper parts of the Southeast River Basins area. Very nearly all the sediment is believed to be suspended fine material with low trap efficiencies. In some reservoirs, small amounts of sediment storage were allotted; and in others, the amount expected was regarded as too small to take into account. No effort was made to establish formal criteria for sediment storage.

Beach erosion study was largely a survey of problem areas and required no planning criteria.

Salinity of ground water due to ocean water encroachment is becoming a serious problem in isolated areas near the coast. Individual case studies and establishment of criteria would be desirable in the future for both planning and design. Salinity of soils is a minor agricultural problem along the coast, but the total area of the narrow band in which this problem exists is a small portion of the Southeast River Basins area, and plans for land use do not require reclamation or treatment of this land. No levels of salinity were used as criteria for estimating the magnitude of the problem.

Water quality data appear in "Water Quality Basic Data, Southeast River Basins," 1961. This report was prepared for the U. S. Study Commission by the U. S. Department of Health, Education, and Welfare on a reimbursable basis. Criteria of water quality for various purposes are given in the water quality portion of Appendix 12, Planning.

SECTION III – METHODS FOR COMBINING FACILITIES

In planning multiple-purpose reservoirs, the usual practice is to choose a site and preliminary size of reservoir and to go through the operations on paper which represent high and low inflows and planned releases. By successive approximations, the process converges on an optimum size and an optimum schedule of operation. Factors involved are stage-area and stage-capacity curves of the proposed reservoir; limits on reservoir stage; scheduled, maximum, and minimum release rates for various purposes; a realistic frequency distribution of inflows; and proper consideration

of full-range streamflow forecasts, which are necessary for effective reservoir operation.

The procedure is one of reconciliation of various needs for water and storage space, and anticipated available water. Those who use a reservoir for recreation prefer that it be operated within a small range of fluctuation, whereas operation for hydroelectric power production necessitates drawdowns in amounts varying with the particular reservoir. One way of resolving this difference would be by scheduling power drawdown at a time of year when recreational uses are at a minimum. Experience with large multiple-purpose reservoirs in the Southeast has shown that, even in the absence of advance planning for recreation as a primary purpose, tremendous recreational uses of the reservoirs have occurred. These uses have, on the whole, been satisfactorily compatible with the primary purposes such as flood control, navigation, and hydroelectric power. Minimum continuous flows downstream may be required for fish and wildlife and other purposes. Maximum releases are limited by possible downstream flood damages. For hydroelectric operation, the most economical scheduling is for intermittent releases.

Because of limitations of time and data for planning, the Commission made no detailed operation studies. A first approximation to reservoir sizing was made for several sites, and a second approximation was made for some of these in two systems. Before the plan is implemented, more detailed work will be required.

For large structures, individual sites were considered, and in most cases, it was necessary to estimate average and extreme flows by interpolating from nearby gage data. For small structures in the Piedmont and Blue Ridge provinces, which are not included as individually enumerated projects, it was assumed that sites with generalized characteristics would be available wherever needed.

SECTION IV – SPILLWAY CRITERIA

The safety of any dam, regardless of its purpose, requires a spillway which can accommodate floodflows. Dams whose failure would be costly, either in the loss of the dam itself or in loss of life or serious property damage from the sudden release of the stored water, require large and often expensive spillways.

Inasmuch as two large rainstorms and resulting floods can occur in rapid succession, as exemplified in the September-October 1929 storms in the Southeast River Basins area, it must be assumed that storage below the spillway crest may not be available at the time of the spillway-design flood. The only storage would be in the prism of water above the spillway crest.

Spillway design requires careful study of each structure and a degree of detail neither warranted nor possible in preliminary planning. Such planning requires only sufficient detail and precision to make sure of the physical feasibility in terms of gross dimensions and to provide an estimate of cost. Accordingly, a generalized approach was used by the Commission for planning spillway capacity. Based on examination of existing criteria, historical storms, and floods, a set of enveloping curves was derived. These curves are shown on Figure 3.20 of this Appendix. Because it was not expedient to route a design flood through each prospective reservoir for a wide range of dam heights and spillway characteristics, the curves of Figure 3.20 show a range of values for each major physiographic province.

The range of values within the pair of curves for each of the physiographic regions provides opportunity to express differences among sites with respect to storage, location, type of spillway, importance of the dam, and damageable values downstream. It will be seen from the plotted points in Figure 3.20 and from consideration of criteria commonly used for important structures that the planning criteria correspond to conservative design criteria.

PART SIX – CONTRACTS AND AGREEMENTS

Introduction

To assist in plan formulation, it has been necessary to gather and interpret basic hydrologic data. Recognizing the need to take advantage of agency know-how and to work effectively with limited time and staff, certain basic data have been prepared by cooperating agencies at the request of the U. S. Study Commission. The following list, by cooperators, describes briefly the work done in compiling and presenting such data.

United States Geological Survey, Department of the Interior

A report, *Some Notes on the Influences of Water Resources on the Economy of the Southeast River Basins,* was prepared September 1959. The report consisted of 24 dittoed pages and 9 illustrations and was prepared for the U. S. Study Commission on a reimbursable basis. It was based on immediately available data and involved no analysis. For each physiographic province, the occurrence of ground water and its relation to surface water were described. Averages and extremes of flow and present development and problems of surface water management were given for principal streams. The report was given to university economists cooperating with the U. S. Study Commission for their information and was used similarly by Commission staff members.

A report, *Hydrologic Characteristics of the Southeast River Basins,* dated 1960, is a compilation of 385 pages, 176 illustrations, and 58 tables describing the flow characteristics of the Southeast River Basins streams and ground water geology, availability, and quality for the major aquifers. A bibliography of some 40 citations is included. Much of the information in this report is summarized in Part Three of this Appendix. The report was prepared for the U. S. Study Commission on a reimbursable basis and was distributed to cooperators and staff members and used in planning water-oriented projects and programs.

A report, *Preliminary Estimate of Water Use in Southeast River Basins, 1960,* consists of 23 pages, including 1 map and 9 tables, and was prepared at no cost to the U. S. Study Commission. It was suggested by the U. S. Geological Survey that the Southeast River Basins be used for the pilot region for the Survey's 1960 water use report and provide the U. S. Study Commission with an advance copy of it. The report gives 1960 water use by basin, purpose, and physiographic region; and distinguishes between withdrawal and consumptive use, and surface and ground water source. With changes in some of the estimated values, the material was later published as U. S. Geological Survey Circular 449.

A report, *The Yield of Sedimentary Aquifers of the Coastal Plain, Southeast River Basins,* dated 1961, consists of 90 pages, 13 figures, 6 tables, and a bibliography of about 20 items. The report was prepared for the U. S. Study Commission on a reimbursable basis and has been used as a source of information on ground water movement and for perspective in considering ground water withdrawals.

United States Weather Bureau, Department of Commerce

The Weather Bureau supplied at no cost copies of unpublished streamflow forecasting procedures, hydrologic maps, and related data.

United States Public Health Service, Department of Health, Education, and Welfare

A report, *Water Quality Basic Data, Southeast River Basins,* dated 1961, is a 195-page summary of water quality data consisting largely of tables and maps. The compilation includes all available physical, chemical, radiological, and bacteriological data for both ground and surface water in each of the eight Study Commission basins. The report was prepared on a reimbursable basis and was distributed to cooperators and staff members and used in planning projects and programs which involved water quality.

Other Agencies

Other agencies engaged in land and water resource development, both State and Federal, furnished data which were used in various studies and in the preparation of this Appendix.

PART SEVEN – NEED FOR DATA AND RESEARCH

Introduction

Observational programs generally have the purpose of showing or measuring the local effects of certain structures or practices, or of covering the country with sampling stations in a pattern that allows no large blank spaces. Data gathering programs, until very recently, have usually had the objective of showing little more than the time, spatial and frequency distributions of single elements such as rainfall, or streamflow, or ground water stage.

In general, the gathering and analysis of data have been process-oriented, with emphasis on instrumentation and methods–how to, rather than why. Public works agencies have arranged, in a few instances, for the data gathering agencies to collect coordinated data for special purposes such as design of spillways. Rarely have hydrologic data been observed and analyzed for the deliberate purpose of planning for resource development. Analysis and interpretation are frequently made by agencies other than those gathering the data. However, this has been done by the Tennessee Valley Authority on the Beech River Watershed in West Tennessee, an area of 300 square miles, and other tributary watersheds. The success of this and other similar programs has amply demonstrated the desirability of hydrologic data collection and analysis as an important part of total resource development.

There is growing recognition of the need to gather data which relate one element to another and which sample physiographic and other parameters for purposes of regional generalization–not only of data but of relationships.

Average Annual Values

An important statistic in planning is the average annual value of rainfall, runoff, evapotranspiration, and other major elements of the hydrologic cycle. A regional generalization of rainfall alone could be prepared by interpolation of data gathered at a sufficient number of points –merely by drawing isolines geometrically. Recent refinements take into account not only the location of stations but also their exposure with respect to objectively defined physiographic parameters, such as direction and steepness of station exposure and whether the station is in a hollow or on a plain or ridge. Similarly, with streamflow, recent regional generalizations take into account climate, watershed shape, and geology and not merely the size of drainage area.

A still more refined analysis has shown promise in the New England-New York Inter-Agency Committee and Delaware River Basin studies in which not only physiographic parameters were used for individual elements but also the elements themselves were coordinated. For example, the average annual rainfall pattern and the average annual streamflow or runoff pattern were derived together, so as to represent a consistent portrayal of their relationship. This is a new approach which requires interdiscipline and interagency cooperation. A nationwide extension of this type of analysis would provide a most useful base for water resources planning.

Relations of Ground Water to Surface Water

A corollary to the coordinated analysis suggested above is the need for better understanding of the relationship of ground water to surface water, particularly in regions such as the Coastal Plain province of the Southeast River Basins, where the distinction between these two categories of water is largely academic, yet where planning must be done. At present, much of the plan is contingent upon a more detailed investigation to be made in the design phase.

Drouth Frequency-Area-Duration Regime

The Corps of Engineers, with assistance from the Weather Bureau, has published a compilation of storm rainfall data which defines for hundreds of large storms their duration-area-depth characteristics. This is an example of purpose-oriented data processing. The purpose was the development of flood control spillway capacities. A similar type of compilation could be made at the other end of the water availability spectrum to develop a portrayal of the

drouth intensity-area-frequency-duration characteristics of the United States. Studies of this type have been made for the Tennessee Valley Authority and in a few other areas.

Rainfall, soil moisture, ground water stages or artesian pressures, and streamflow are all used as drouth measures. Refined rainfall functions of various kinds have been related to soil moisture and are being used in forecasting streamflow and for planning supplemental irrigation. Generalized functional relationships can be established among other elements of the hydrologic cycle for similar purposes.

Draft Storage Frequency Generalizations

In a water supply problem, one of the methods of ascertaining the amount of storage required is mass-curve analysis. This can be generalized in the form of draft-storage curves, as was done for the 1954-56 drouth, and for the 10-year 7-day low flows, which were used in Commission planning. A further refinement would be completion of the frequency spectrum of the draft-storage curves. Then, instead of arbitrarily selecting a 10-year, or a 1954 base for planning, an optimum can be chosen along the frequency scale in the light of economic analysis. Preparing consistent and valid regional generalizations of draft-storage-frequency relationships would not only be superior in quality to improvising on a site-by-site basis but also in the long run would probably be less total work.

Flood Volume Frequencies

Much work has been done with flood frequencies. But nearly all the work has been related to peak flows instead of volumes. For planning storage, it is necessary to know the volume in addition to the peak rate. The Corps of Engineers has demonstrated, in sample drainage areas, how frequency methods can be applied to flood volumes for a range of duration. However, the number of samples is too small for regional generalization. An extension and refinement of this work would provide a good basis for estimating storage requirements in ungaged areas and would provide a consistent set of criteria.

Generalized Rainfall-Runoff Relationships

Rainfall-runoff relationships are needed on a generalized basis for an increasing number of small watersheds. For large watersheds, methods of the Weather Bureau, Corps of Engineers, and Bureau of Reclamation are available over much of the United States. These are based largely on observed data but rarely for drainage areas smaller than 500 square miles. The Soil Conservation Service uses methods which require knowledge of agricultural sciences for determining land-use influences on runoff for flood prevention and drainage for relatively small areas. Aside from need to refine and achieve agreement on physical relationships, there is the need for generalization for consistent planning.

Generalized Unit Hydrographs

A corollary of the need to generalize rainfall-runoff relationships for small areas is the need for generalized synthetic unit graphs for small areas. In the Corps of Engineers project CW-153, Snyder's method has been applied widely, and such methods could be extended for general use in planning. The Soil Conservation Service method of design hydrograph computations is easily extended to the development of unit graphs.

Generalized Reservoir Routing Methods

As the number of small detention reservoirs increases, a need will arise for routing floods to determine their aggregate effects over extended distances. Instead of laboriously working up individual routings for each reservoir, it would be useful to generalize, possibly in terms of generalized recession curves, to reflect not only the accumulation of uncontrolled tributary inflow with increasing distance downstream from the reservoir but also the peak-flattening effect of channel storage. The recession curves might reflect the characteristics of various frequency criteria, storage, and outflow curves of the reservoir and also the runoff characteristics of the uncontrolled area downstream. Such a generalization would be helpful for planning.

Production Functions

Production function is a term used by economists and others in referring to the relationship between the amount of water and other resources used in producing a given result. The present state of the art of water resources planning limits the application of this technique

largely to expressions of subjective judgment. As an illustration, it is convenient to discuss a possible production function for supplemental irrigation.

Irrigation in a humid region is part of a complex of measures for ensuring a crop and for increasing yields. Irrigation alone is not as effective as when combined with some optimum amount of fertilizer, pesticides, seeding rate, and other factors. To determine the optimum combination of these factors, a multivariate analysis would show its joint effects on crop yield.

Another example, to illustrate the utility of a production function in water resources planning, is the relation of fish and wildlife benefits to streamflow regime. Certain changes in stream regime are known to damage fish and wildlife habitat, and thought has been given recently to artificially improving the habitat through stream regulation. Questions to be answered are the amount of storage and kind of control for the best habitat and the effects of lesser or different type of stream control on the quality of habitat. Only by evaluating type of regime with habitat can the optimum type of control be achieved for best results, and in coordination with other needs for river regulation. Much more has been done with relation of habitat to water quality than to rate of flow or to seasonal variation in stage.

Spillway Criteria for Intermediate Size Dams

There is an unexplored area in the spillway criteria for structures too small for consideration of the maximum probable flood[1] yet too large for any frequency criteria that can be defined by existing record lengths. Most flood frequency methods employ distributions that have no asymptote, yet there is a ceiling imposed by the conventional maximum probable flood. This is a difficult problem, and it involves many disciplines, yet it must be faced. At present, the burden is placed on some adjective hazard category with corresponding design criteria, such as half or three-fourths of the maximum probable. There might be some economy with a continuous scale and a more rational basis than with broad adjective categories.

Operations Research

Operations research, such as that stemming from Water Resource Seminars at Harvard University, has as yet had relatively little practical application but should be continued. In planning, much reliance is often placed on judgment — not only as to the magnitudes of pertinent factors but also as to the manner in which they are combined to make a decision. A discipline and procedure are necessary so that judgment can be distinguished from other ingredients that lead to decision making, so that reviewers of a plan can evaluate the considerations instead of merely the conclusion, and so that new planners can be trained systematically instead of requiring years of experience. Such research would include evaluation of forecasting and of proper balance between data and analysis for regional generalization.

Federal-State Cooperation

Some Federal agencies have authority to accept money from States to make special observations. In this way, special local requirements can be met and the local beneficiaries properly share a major part of the cost. Other Federal agencies do not have this authority, and serious problems arise where there is a local need for special observations or services which require standard methods or instruments, yet the local beneficiaries can only press for favored allocation of federally financed programs. It would further the hydrologic basis for planning, if authority such as some agencies have was extended to other Federal agencies.

Water Quality Studies

Much of the foregoing discussion of need for data and research with respect to availability and management of water applies as much to quality of water as to quantity. It is important to maintain a continuing program of field observation and laboratory analysis of quality of surface and ground water. The effects on water quality of multiple-purpose projects and other programs which use or affect water quality should be examined in the process of planning and design.

[1] The "maximum probable flood" is here used to mean the most severe flood with respect to flood peak that may be expected from a combination of the most critical meteorological conditions that are reasonably possible on the drainage basin. Hydrometeorological Report No. 33 by the Weather Bureau gives the basis for estimating the discharge of such a flood.

AD-A041 850 UNITED STATES STUDY COMMISSION SOUTHEAST RIVER BASINS--ETC F/G 8/6
PLAN FOR DEVELOPMENT OF THE LAND AND WATER RESOURCES OF THE SOU--ETC(U)
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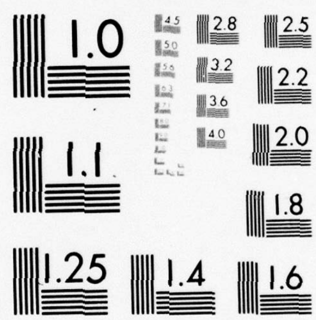
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PART EIGHT – BIBLIOGRAPHY

Introduction

An effort has been made to study every publication which would be helpful in supplying data or methods for (1) evaluating the climatic and water resources of the study area; (2) understanding the status and operations of existing projects, programs, and investigations; (3) assessing present and future water use and problems; and (4) examining criteria and methods commonly used by agencies in planning and managing water resources. Several hundred scientific papers, professional reports, data compilations, agency manuals, and other sources were studied and are cited on cards in the working papers of the Commission. In addition, much open-file data were made available for study. Much of the material examined was digested in a way that would make direct reference inappropriate. In many instances the development of information required examination and weighing of selected portions of several sources.

Basic Data

Published data are available generally in periodicals of the U. S. Geological Survey dealing with surface water supply, quality of surface waters, water levels, and artesian pressures; and in the U. S. Weather Bureau publications on climatic summaries and local climatic data. Such data also appear in various other compilations and summaries of these basic-data agencies.

In addition to the basic data and summaries, these agencies have prepared analyses and interpretation of data, some of which were specially pertinent to this Appendix and are listed below.

U. S. Geological Survey. *USGS Circular No. 449, Preliminary Estimate of Water Use in Southeast River Basins 1960*, Washington, D. C., 1961.

U. S. Weather Bureau. *Research Paper No. 34, Predicting the Runoff from Storm Rainfall*, Washington, D. C., 1951.

U. S. Weather Bureau. *Technical Paper No. 36, North Atlantic Tropical Cyclones*, Washington, D. C., 1959.

U. S. Weather Bureau. *Technical Paper No. 37, Evaporation Maps for the United States*, Washington, D. C., 1959.

U. S. Weather Bureau. *Technical Paper No. 40, Rainfall Frequency Atlas of the United States*, Washington, D. C., 1961.

U. S. Weather Bureau. *Hydrometeorological Report No. 33, Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian*, Washington, D. C., 1956.

U. S. Public Health Service. *Water Quality Basic Data, Southeast River Basins*, 1961.

U. S. Geological Survey. *The Yield of Sedimentary Aquifers of the Coastal Plains, Southeast River Basins*, Joseph T. Callahan, 1961.

Methods, Programs, and Criteria of Federal Agencies

Methods and criteria of the Corps of Engineers and Soil Conservation Service are given in many volumes of engineering manuals, handbooks, and other guides. In addition to these sources, the Corps of Engineers, for example, has reported on investigations, of which the following publication is cited, *Storm Rainfall in the United States*, Washington, D. C., 1945. A useful summary of Federal agency programs referred to in preparing this Appendix is the report and the various prints of the Senate Select Committee on National Water Resources, Washington, D. C., 1961.

Scientific and Professional Publications

Many organizations publish results of investigations related to water resources development; the American Society of Civil Engineers and the American Geophysical Union are particularly noteworthy. Papers of these organizations which were used directly in this Appendix include the following:

Journal of Geophysical Research of the American Geophysical Union. *Water Deficits and Irrigation Requirements in the Southern United States*, van Bavel, C.H.M., No. 10, 1959.

Transactions, American Society of Civil Engineers, *Flood-Control Operation of Tennessee Valley Authority Reservoirs*, Rutter, Edward J., Paper No. 2443, v. 116, 1951.

State Publications

States in the study area publish bulletins, circulars, reports, and newsletters through their ag-

ricultural experiment stations, water commissions, and other organizations. Some of these publications are periodicals, such as the Georgia Mineral Newsletter, and others are the results of special investigatio . Examples of noteworthy State publications follow.

Geological Survey of Alabama, Special Report 20, *Water Resources and Hydrology of Southeastern Alabama*, 1949, prepared cooperatively by U. S. Geological Survey.

Florida Water Resources Study Commission Report to the Governor of Florida and the 1957 Legislature, *Florida's Water Resources*, 1956.

Georgia Department of Mines, Mining, and Geology, Georgia Geological Survey Bulletin No. 65, *The Availability and Use of Water in Georgia*, 1956, prepared cooperatively by U. S. Geological Survey.

APPENDIX 11

PLAN FOR DEVELOPMENT
OF THE
LAND AND WATER RESOURCES
OF THE
SOUTHEAST RIVER BASINS

ENGINEERING AND COST

APPENDIX 11

TO REPORT OF
UNITED STATES STUDY COMMISSION
SOUTHEAST RIVER BASINS
1963

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• Served less than 18 months.
•• On long-term loan from another agency.
ø Deceased April 1962.
øø Deceased January 1963.

FOREWORD

This Appendix supplements the Report and the other appendixes by setting forth the background data of the engineering studies, the standards used, the procedures followed, and the costs determined as a result of the studies.

This Appendix is presented in six parts. Part One gives the basis for the engineering studies and a brief description of the study area from the engineering standpoint. Part Two deals with the general geology of the Southeast. Part Three covers maps and their uses; Part Four describes such engineering procedures as site investigation, site selection, and design; and Part Five presents the bases for cost estimating for various purposes, the sources of data, and devices used. Part Six summarizes estimated costs by purposes and by basins. The matter contained herein is pertinent to the comprehensive plan. The reader is urged to consider the Report in the aggregate rather than to consider selected material out of context.

The Report of the United States Study Commission summarizing the plan for the Southeast River Basins was made in response to the provisions of Public Law 85-850 (72 Stat. 1090) dated August 28, 1958, which established the United States Study Commission, Southeast River Basins. Public Law 85-850 is reproduced in Appendix 13.

The authorizing Act provided for an integrated and cooperative investigation to formulate a comprehensive and coordinated plan for:

(1) Flood control and prevention;

(2) domestic and municipal water supplies;

(3) the improvement and safeguarding of navigation;

(4) the reclamation and irrigation of land, including drainage;

(5) possibilities of hydroelectric power and industrial development and utilization;

(6) soil conservation and utilization;

(7) forest conservation and utilization;

(8) preservation, protection, and enhancement of fish and wildlife resources;

(9) the development of recreation;

(10) salinity and sediment control;

(11) pollution abatement and the protection of public health; and

(12) other beneficial and useful purposes not specifically enumerated in the Act.

The comprehensive plan for the Southeast River Basins was formulated to meet the needs of the area for land and water resources development to the year 2000. Projects and programs existing and under construction in 1960 are included in the plan, but only 1960-2000 developments are analyzed.

The plan for the development of the resources of the Southeast River Basins is the result of cooperative work of Federal, State, and local and private agencies having interest in the area and knowledge of its needs and requirements. Public hearings were held early in the planning process to obtain firsthand knowledge of conditions and problems in the study area and to secure suggestions for their solution. Throughout the study, liaison was maintained with interested groups and agencies by means of conferences and committee and advisory group meetings. When a tentative plan was developed, public presentations were made by the Commission to inform interested persons and organizations and to request comments. These comments were considered in preparing the final plan and Report.

Although many individuals, groups, and agencies have participated in the studies, the Commission takes full responsibility for the plan and for the projections, assumptions, and analyses on which it is based.

The Commission plan for the Southeast River Basins is supported by data contained in 13 appendixes. Data on the plan for development of the resources in the eight geographic areas studied in the Southeast River Basins are contained in Appendixes 1 through 8. Technical data and information applicable to both the entire study area and the several geographic areas are contained in Appendixes 9 through 13. The

appendixes to the Commission Report are as follows:

Appendix	Title
1	Savannah Basin
2	Ogeechee Basin
3	Altamaha Basin
4	Satilla-St. Marys Basins
5	Suwannee Basin
6	Ochlockonee Basin
7	Apalachicola-Chattahoochee-Flint Basins
8	Choctawhatchee-Perdido Basins
9	Economics
10	Hydrology
11	ENGINEERING AND COST
12	Planning
13	History and Organization of the Commission

U. S. STUDY COMMISSION
SOUTHEAST RIVER BASINS

APPENDIX 11

ENGINEERING AND COST

CONTENTS

CONTENTS—Continued

TABLES

PART ONE – INTRODUCTION

In carrying out the purposes of Public Law 85-850, engineering and cost estimating studies were made by both the Commission and cooperating agencies to formulate, evaluate, and select projects and programs for inclusion in the comprehensive plan.

A high degree of accuracy in engineering investigations, with the time and expense necessary to attain it, is not warranted for a study of this nature. The engineering procedures used reflect this policy in many instances by utilizing experience curves and other short-cut methods in general use for reconnaissance studies. In those cases where more detailed designs and estimates were available or could be readily obtained, they were used in the studies.

In general, information on subsurface conditions was obtained from available data rather than from special geologic investigations at project sites. Project layout and design followed conventional patterns. Estimates were generally based on costs of similar work in this area with modifications as necessary to suit conditions at sites considered and for adjustment to the January 1960 price level adopted.

The study area presents a favorable picture to the engineering designer and the construction engineer, except for foundation conditions in some areas. Construction materials are generally found within reasonable distances and the transportation network is adequate for delivery to most sites. Labor is available at wage rates below the United States average, and the lack of extreme cold weather permits year-round construction activity.

PART TWO – GEOLOGY

The area of the Southeast River Basins includes portions of three major geologic provinces, the Blue Ridge, the Piedmont, and the Coastal Plain.

The Blue Ridge province extends only a short distance into the northern portion of the study area. As part of the Appalachian Mountain chain, it is underlain by highly metamorphosized quartzites, phyllites, gneisses, schists, and other complex metamorphic rock. The rivers have incised deep valleys in this rock, providing excellent damsites, some of which have already been developed. Some weathering and jointing of the bedrock is normally encountered, but such foundation defects can be corrected by customary good foundation treatment procedures. In general, the rock is satisfactory for dam foundations.

The Piedmont province is underlain by metamorphic and igneous rocks. The metamorphic rock is an intricate series of gneisses, schists, and complex intermediate types. The igneous rock is generally granite intrusives with some minor diabase dikes. Damsites in this area, where the stream valleys are wide, normally require earth embankments extending from the river section to the abutments. Deep-rock weathering occurs in many places, requiring excavation to considerable depth to reach a suitable foundation. With the weathered rock removed, the foundation rock is hard and sound and, except for local jointing, requires a minimum of remedial treatment.

The rock underlying the Coastal Plain is marine sediment varying from the oldest, or Tuscaloosa formation, at the contact with the Piedmont, through progressively younger sediments toward the Atlantic Ocean and the Gulf of Mexico. The materials vary from unconsolidated sands and clays through partially consolidated sandstones, claystones, and various textured limestones. Areas of hard limestone are mostly localized. Because of the broad river valleys, dam construction in this area requires long earth embankments to tie the river sections of the dam to the abutments. By careful site selection it is sometimes possible to found dams on limestone or on partially consolidated sediments such as claystone, siltstone, or chalk. Where no consolidated material can be found, structures are often founded on bearing piles, with a steel sheet piling cutoff through the pervious material. Specialized foundation treatment is frequently necessary to provide adequate dam foundations in this area. Cavernous limestone formations are common near the Gulf of Mexico and for considerable distances up the valleys of the rivers emptying into the Gulf. Such formations require extensive grouting.

PART THREE – MAPS AND MAPPING

The entire study area is covered by topographic maps produced by the Army Map Service, Corps of Engineers, U. S. Army. These maps are published and distributed for civilian use by the U. S. Geological Survey. The scale is 1 to 250,000, about 1 inch = 3.94 miles, and the contour interval is generally 50 feet, with some supplementary 25-foot contours. In certain mountain areas the contour interval is 100 feet. The sheet size is 24 inches by 34 inches. Each sheet covers 1° of latitude and 2° of longitude. Woodlands are shown by a green overprint. Maps in the 1:250,000 scale series are designated by name and number as shown on Figure 3.1.

In addition to the 1:250,000 scale quadrangles, the Geological Survey is making, as a continuing program, a series of larger scale topographic maps to cover the United States, Puerto Rico, and the Virgin Islands. Completed maps in this series which provide coverage in the study area were used extensively by the Commission staff for site location and other purposes. Under the general plan adopted, the unit of survey is a quadrangle bounded by parallels of latitude and meridians of longitude. Quadrangles covering 7½-minutes of latitude and longitude are published at the scale of 1:24,000, 1 inch = 2,000 feet; or 1:31,680, 1 inch = ½ mile. Quadrangles covering 15-minutes of latitude and longitude are published at the scale of 1:62,500, 1 inch = about 1 mile, and quadrangles covering 30-minutes of latitude and longitude are published at the scale of 1:125,000, 1 inch = about 2 miles. A few special maps are published at other scales. Each quadrangle is designated by the name of a city, town, or prominent natural feature shown on it. The maps are printed in three colors with cultural features and lettering in black, water bodies and streams in blue, and contour lines in brown. On some maps additional colors are used, such as green for woodland and red for highways.

The contour interval of the 7½- and 15-minute quadrangles varies with the scale of the map and the relief of the terrain. It is generally 10 feet except in the rougher terrain where a 20- 40- or 80-foot interval is used. The 30-minute quadrangles generally show 50-foot or 100-foot contours.

Tables 3.1 and 3.2 show index numbers and titles of the harbor and Intracoastal Waterway charts and the coast charts shown on Figures 3.5 and 3.6, respectively. These charts are published by the U. S. Coast and Geodetic Survey and may be obtained from the headquarters of that agency, Washington 25, D. C., or from distributors such as marine supply houses in port cities.

TABLE 3.1

Harbor and Intracoastal Waterway Charts

Number	Title
440	Savannah River and Wassaw Sound
573	Ossabaw Sound and St. Catherines Sound
574	Sapelo and Doboy Sounds
575	Altamaha Sound
447	St. Simon Sound, Brunswick Harbor and Turtle River
448	St. Andrew Sound and Satilla River
453	Fernandina Harbor to King Bay
577	Nassau Sound to Jacksonville
569	Approaches to St. Johns River, St. Johns River Entrance
839	Port Royal Sound to Johnson Creek
840	Johnson Creek to Brunswick River
841	Bruswick River to Nassau Sound
842	Nassau Sound to Mantanzas Inlet
484	St. Marks River and Approaches
865	St. George Sound to Apalachicola Bay
866	Apalachicola Bay to Lake Wimico
867	Lake Wimico to Overstreet and St. Joseph Bay Entrance
868	Overstreet to St. Andrew Bay
869	St. Andrew Bay to West Bay Creek
870	West Bay Creek to Choctawhatchee Bay Entrance
871	Choctawhatchee Bay Entrance to Pensacola
872	Pensacola to Bon Secour Bay
489	St. Andrew Bay
490	Pensacola Bay
413	Pensacola Bay Entrance

The Atlantic and Gulf coasts, including the harbors and the Atlantic and Gulf Intracoastal Waterways, are covered by charts issued by the U. S. Coast and Geodetic Survey. Coast charts are prepared at a scale of 1:80,000 and harbor charts generally at 1:40,000 or 1:20,000. Where greater detail is desirable some harbor charts have scales of 1:15,000 or 1:10,000. Intracoastal Waterway charts are at 1:40,000 scale. All charts show water depths, navigation aids, and coastal landmarks.

TABLE 3.2

Coast Charts

Number	Title
1240	St. Helena Sound to Savannah River
1241	Tybee Island to Doboy Sound
1242	Doboy Sound to Fernandina
1243	Amelia Island to St. Augustine
1259	Crystal River to Horseshoe Point
1260	Horseshoe Point to Rock Islands
1261	Apalachee Bay
1262	Apalachicola Bay to Cape San Blas
1263	St. Joseph and St. Andrew Bay
1264	Choctawhatchee Bay
1265	Pensacola Bay and Approaches

Much of the study area, mostly in Alabama and Georgia, lacks coverage by any U. S. Geological Survey topographic maps except the 1:250,000 scale quadrangles. The remaining area is nearly all covered by either 7½-minute or 15-minute quadrangles or both. Some of it has 30-minute coverage only, and some 30-minute coverage is provided for areas which are also shown on the more detailed maps.

Highway maps are issued by the State highway authorities for each State and for each county. Highway maps published by oil companies also have been used extensively. All of these highway maps are generally dependable for road systems and town locations but are not suitable for uses requiring accurate location of physical features, particularly streams.

The Corps of Engineers District Offices in Savannah, Georgia; Jacksonville, Florida; and Mobile, Alabama, have produced many maps for their own purposes which have been useful in the studies. These include the "Project Maps" in separate volumes by Engineer Districts and the maps shown in the reports by States entitled "Water Resources Development by the U. S. Army Corps of Engineers."

The Commission prepared maps for preliminary use in report drafts, for such purposes as public presentations, Commission and group meetings, and for reproduction in final form in the Report and the appendixes.

Some have been prepared by cooperating agencies for preliminary and information purposes. In 1959, the U. S. Geological Survey made under a reimbursable arrangement a base map of the study area in color, with a relief overlay, which was used as the base for many of the preliminary and study maps as well as those appearing in the Report. The Department of Agriculture furnished maps delineating watershed planning units and land resource areas. In a few cases maps have been prepared for the Commission by commercial drafting services.

Aerial photographs have been utilized to a considerable extent in site studies. They have been useful in conjunction with available topographic maps, particularly those made from older survey data. The Commodity Stabilization Service and Soil Conservation Service of the U. S. Department of Agriculture have complete aerial photo coverage of the study area. The Corps of Engineers has aerial photographs of a number of areas in connection with construction projects. These photographs, which include civil works project sites and some military installations, have been available for use by the Commission.

The best available geologic maps of the Southeast River Basins area are the Geologic Maps prepared by the U. S. Geological Survey and the States of North Carolina, South Carolina, Georgia, Alabama, and Florida. Although these maps have not been revised for many years, they provide a general picture of the many geologic formations. Some detailed geologic work including mapping has been done in local areas, generally by students studying for higher degrees in geology. Such mapping is generally not applicable to any proposed site. Information on geologic data for local areas was obtained from the State Geologists, who are familiar with all geologic mapping which has been accomplished in their respective States. Adequate geologic mapping

TOPOGRAPHIC MAPPING-1963

SCALE 1:250,000

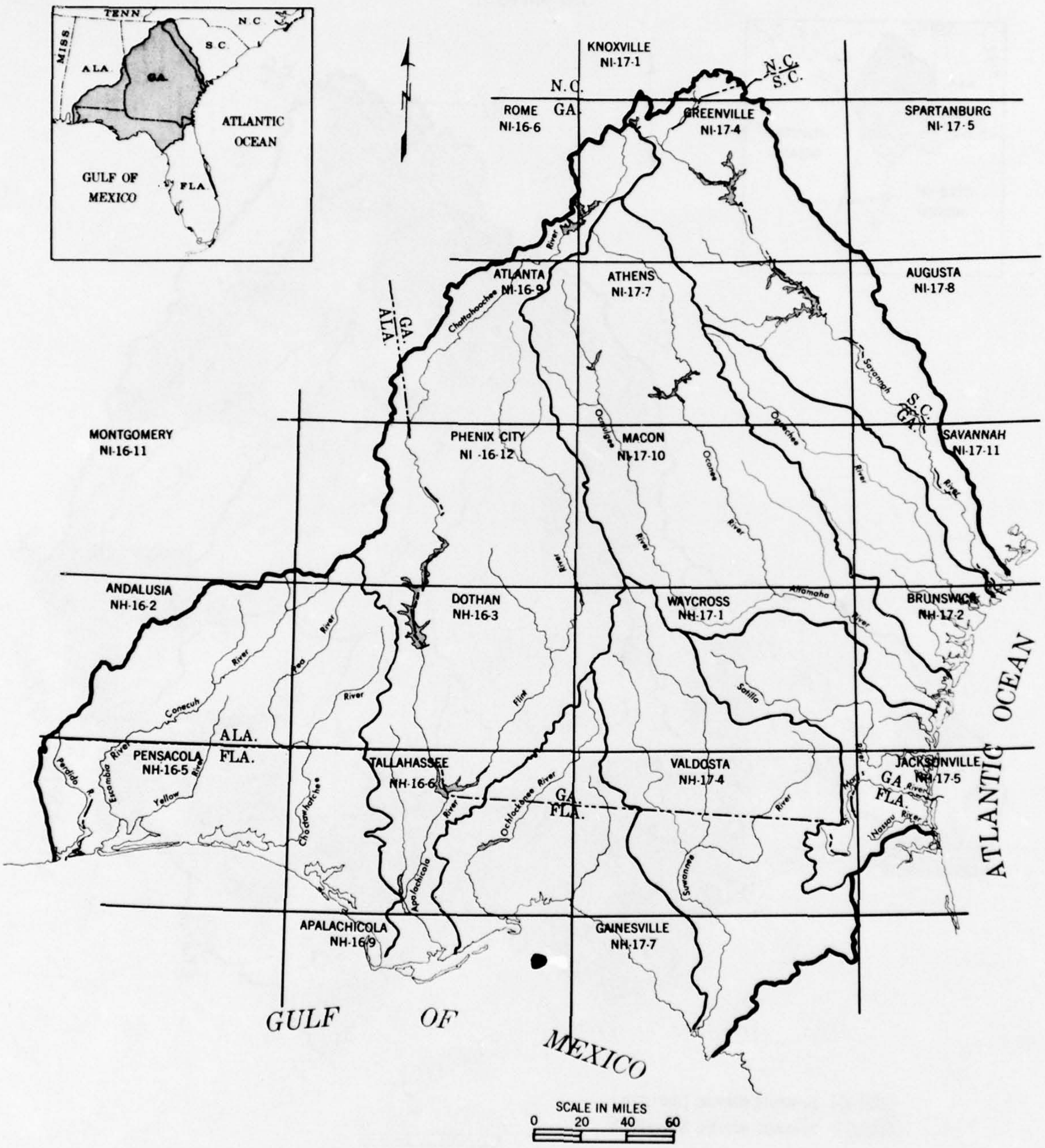


Figure 3.1

TOPOGRAPHIC MAPPING 1963

7½-MINUTE

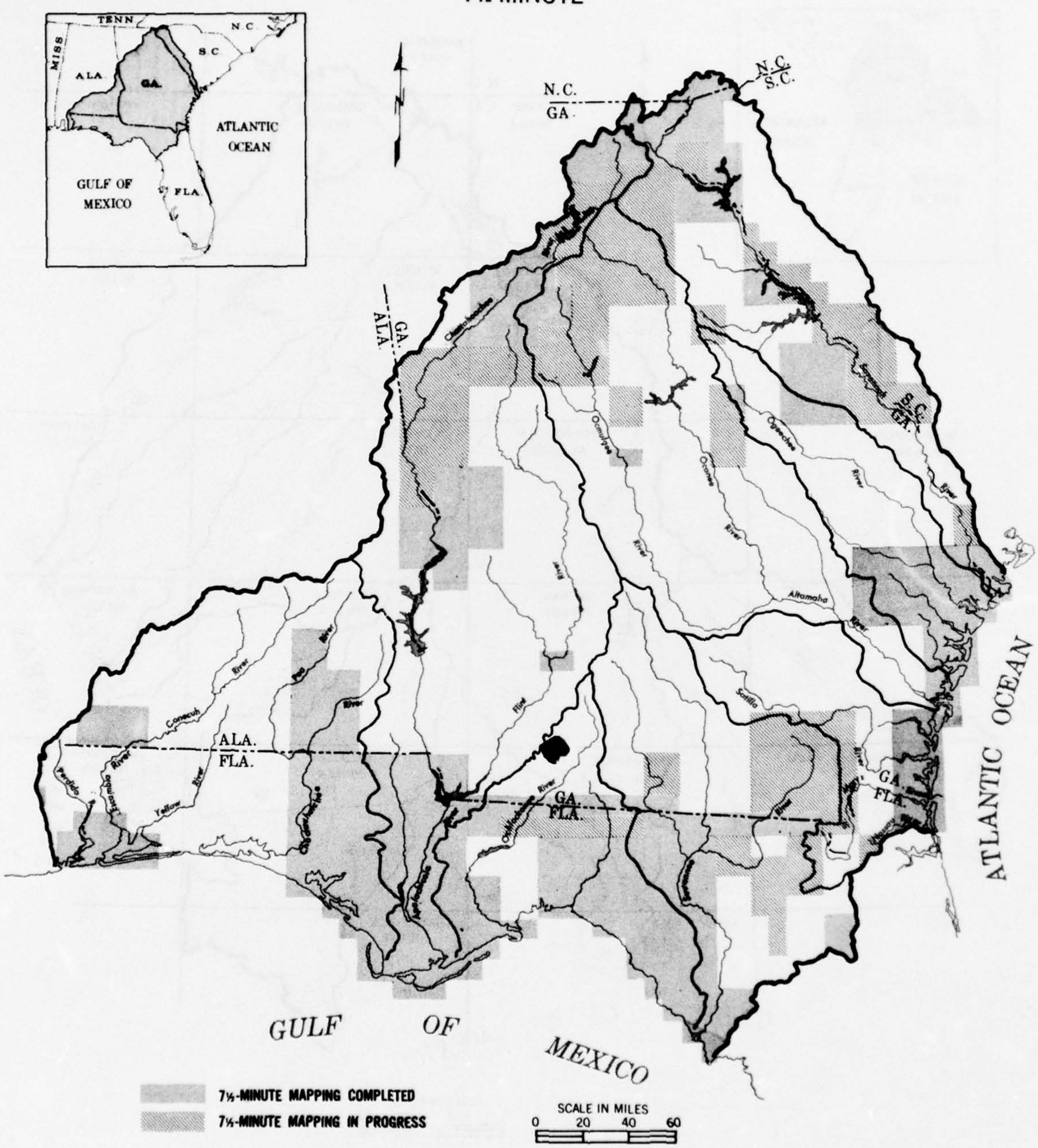
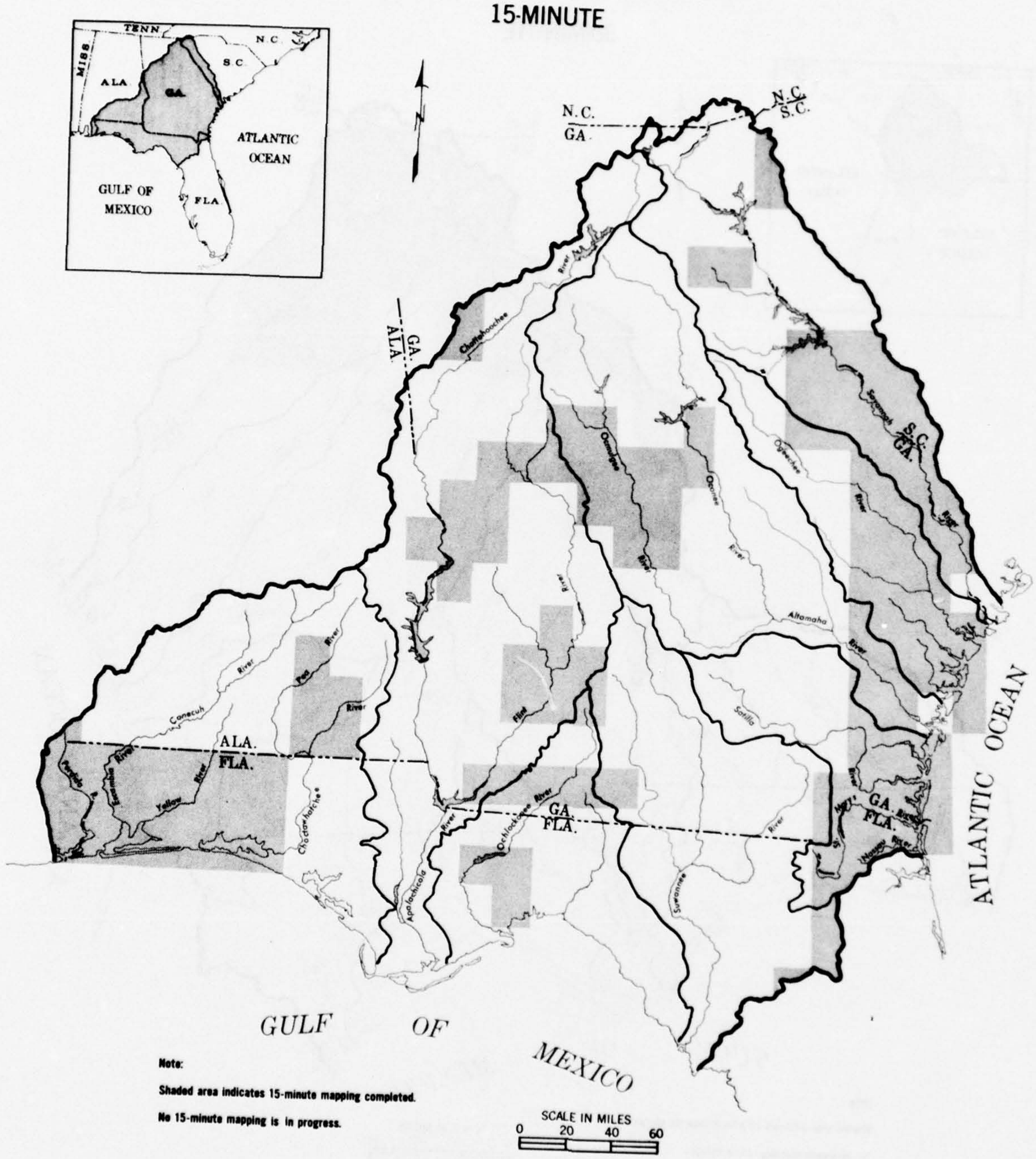


Figure 3.2

TOPOGRAPHIC MAPPING - 1963

15-MINUTE



Note:

Shaded area indicates 15-minute mapping completed.

No 15-minute mapping is in progress.

Figure 3.3

TOPOGRAPHIC MAPPING-1963

30-MINUTE

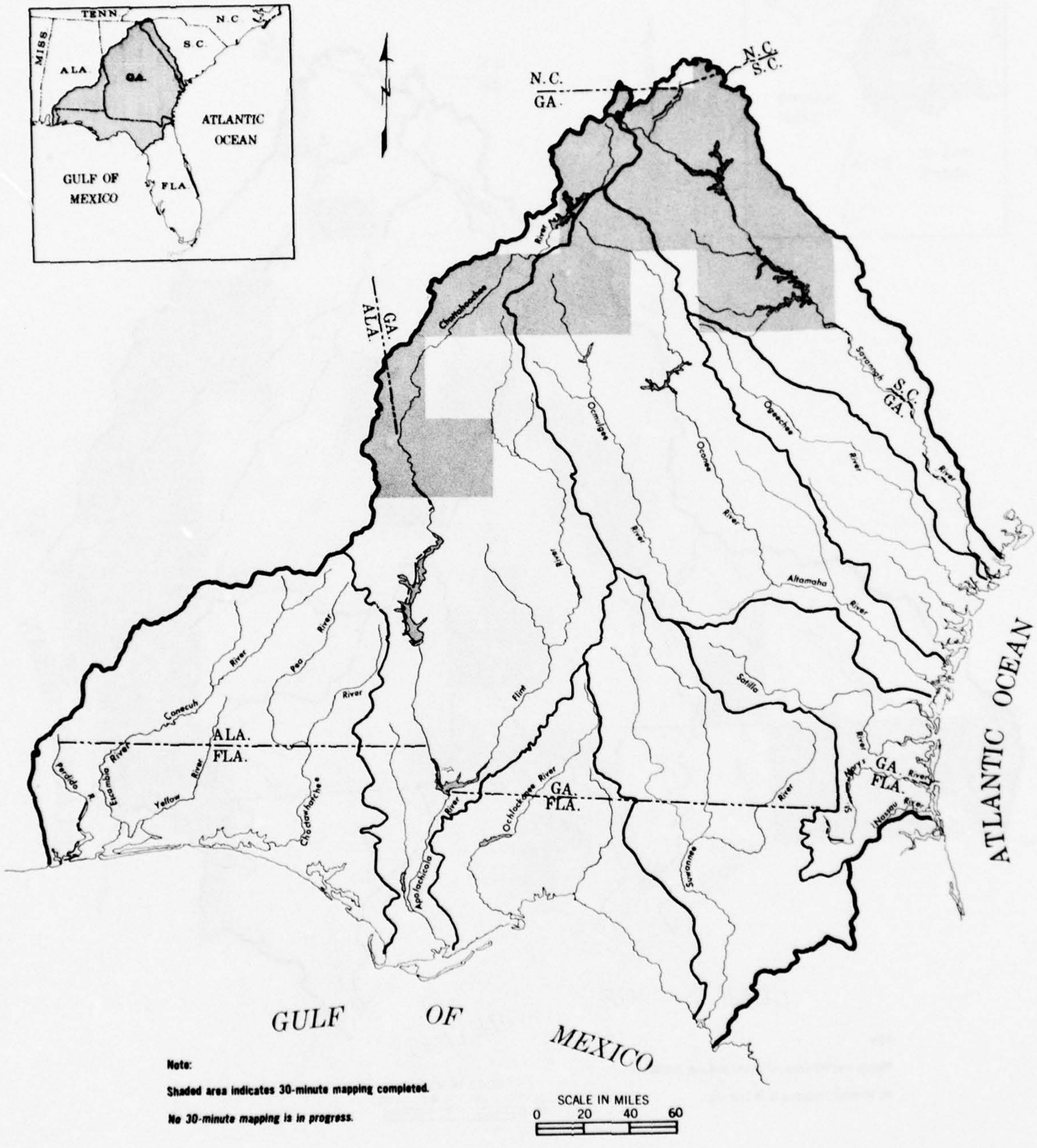


Figure 3.4

HARBOR AND INTRACOASTAL WATERWAY CHARTS- 1960

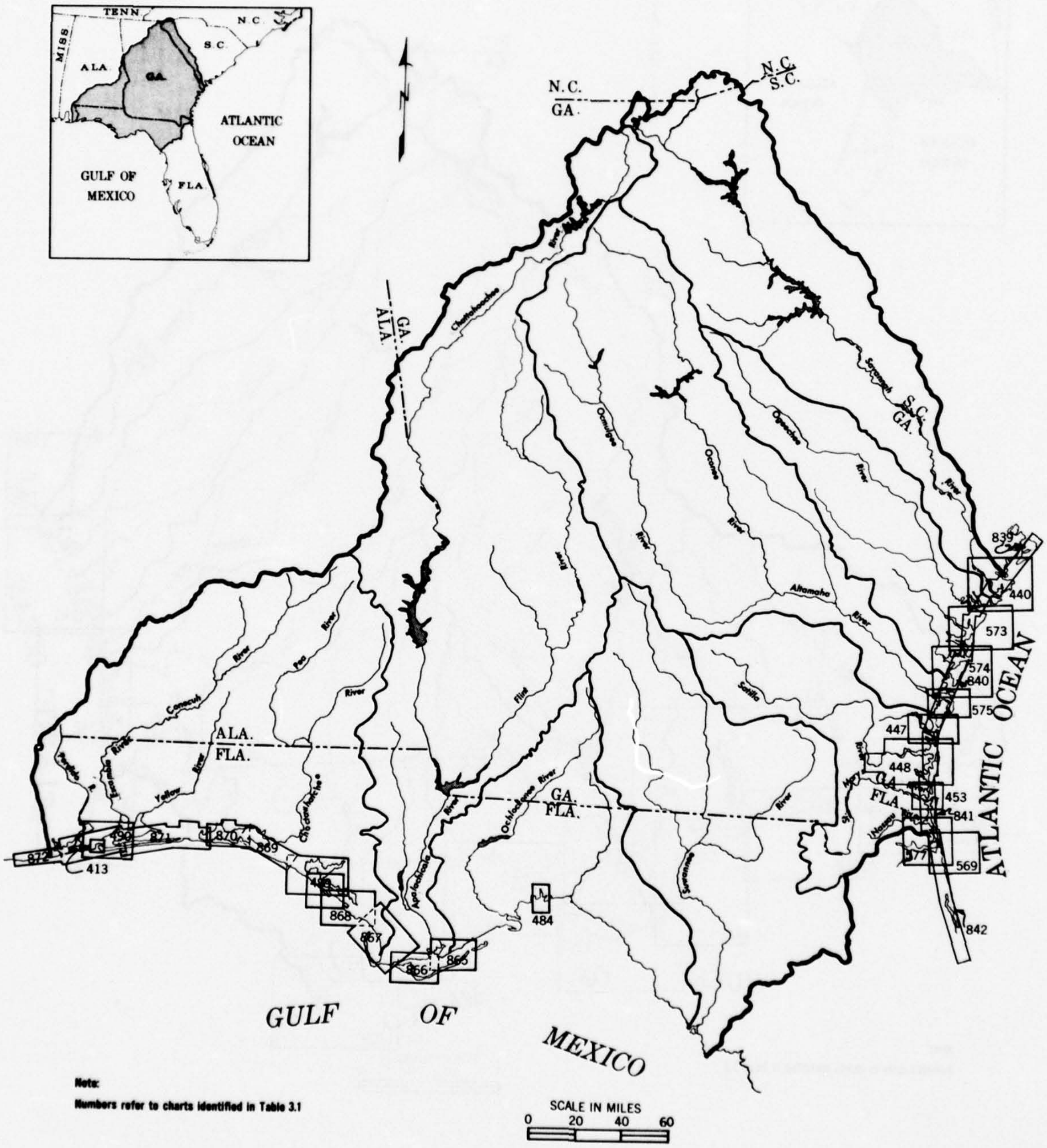


Figure 3.5

COAST CHARTS-1960

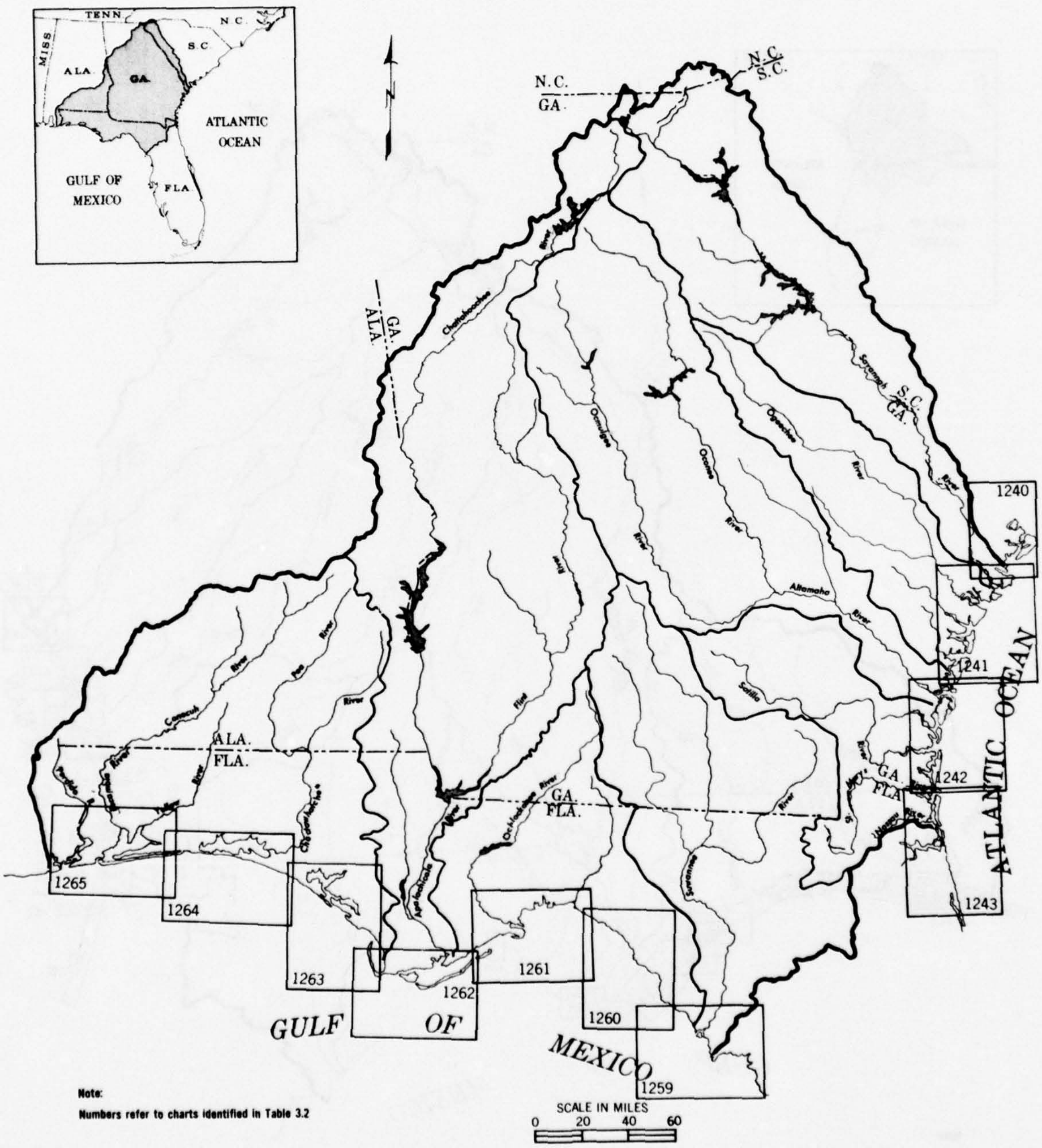


Figure 3.6

for individual site studies was generally not available and should be made separately for each site by detailed field investigations.

The U. S. Geological Survey made especially for the Commission four maps showing locations of economically important deposits of metallic and nonmetallic minerals, organic fuels, and construction materials.

The topographic maps published by the U. S. Geological Survey and which may be obtained from the headquarters of that agency, Washington 25, D. C., have been utilized more extensively than any others, principally because of the topographic detail shown. The 1:250,000 scale quadrangles, the only ones which provide coverage for the entire study area, are adequate in both scale and contour interval for limited purposes. Surveys from which revisions of these maps have been made date from 1950 to 1957.

The 30-minute maps which, in some parts of Alabama and Georgia particularly, provide the only coverage on a scale larger than 1:250,000, are generally very old. In most cases the date of survey is prior to 1900. Many were made from surveys prior to 1896 when reconnaissance methods were widely used. Data shown on these 30-minute quadrangles were used with caution and were generally verified by other maps or by field observation.

The 15-minute and 7½-minute quadrangles show data based for the most part on surveys made since 1941. However, most of the 15-minute quadrangles east of longitude 82°30′ and two quadrangles in central Georgia are based on surveys made between 1909 and 1941.

The 15-minute and 7½-minute quadrangles are generally adequate in both scale and contour interval for determining drainage areas, reservoir areas, and location of structures to the degree of accuracy needed for this Report. The 30-minute quadrangles are generally inadequate in these respects.

State highway maps, coast charts, and special maps were generally adequate for the purpose for which they were used.

To provide the control desirable in connection with a program to correct mapping deficiencies in the study area to reasonably adequate standards is estimated by the U. S. Geological Survey to require more than 2,300 marked control stations for horizontal control and about 15,000 linear miles of leveling for vertical control. A total of about 325 man-years would be required to complete the work.

Nearly every aspect of the studies on which the Report is based has involved the use of maps, either as aids in making the studies or as a means of showing the results. In using maps as aids, it has been necessary to consider the accuracy and completeness of the data shown, with particular attention to date of survey, scale, and contour interval. The best available maps covering portions of the study area adequately meet national map accuracy standards, but those covering most of the study area are only fair to good in reliability. However, independent checks of features critical to any project being considered were generally made. Coast charts are generally kept up to date and information thereon was accepted with due consideration to the dates shown for soundings.

Topographic maps were essential in dam and reservoir studies to determine drainage areas and the location of structures. Relocations were determined by reference to State highway and other maps.

Maps were used to show graphically the material presented for most purposes considered in the Commission studies. Standard base maps of the study area and for each basin were prepared by the Commission for use throughout the Report and its appendixes. Material pertinent to the various purposes is shown by means of reproduction of the base maps with overlays and appropriate modifications and by other maps specially prepared.

PART FOUR – ENGINEERING PROCEDURES

SECTION I – SITE INVESTIGATIONS

Site investigations for specific projects were made where economic studies indicated a need for such projects now or by the year 2000. Engineering and economic feasibility were considered for each project. Alternative means of meeting the needs by either a single-purpose or a multiple-purpose project were investigated.

Since dams and reservoirs are prominent among the construction projects considered in the plan, this type of project is used as an example of site investigation procedures. Similar procedures, adapted to the purpose involved, were used for other types.

For the most part, reliance was placed on existing data such as geologic and topographic maps, published or estimated hydrologic information, and known conditions at nearby projects. Hydrologic information included U. S. Geological Survey publications such as "The Availability and Use of Water in Georgia;" "Water Resources and Hydrology of Southeastern Alabama;" "Flow Duration of Georgia Streams," prepared in collaboration with the State of Georgia; "Compilation of Records of Surface Waters of the United States through September 1950," Parts 2A and 2B; and the annual periodical "Surface Water of the United States," Parts 2A and 2B. Appendix 10 provides more detailed information on hydrology.

The results of extensive investigations by other agencies for proposed construction, and actual agency plans for construction, were utilized in studying similar sites. These data are useful in evaluating foundation conditions likely to be encountered, specific streamflow characteristics, availability of construction materials, and other aspects of the site. Agency plans for similar construction were helpful in indicating suitable site layouts and structure design and in estimating costs.

Much basic data pertinent to site investigations were compiled during the study. This included information on stream and soil characteristics and the location of transportation routes, bridges, powerlines, and pipelines.

In August of 1961, the Commission negotiated a contract with George Aase and Associates of Tallahassee, Florida, a consulting firm specializing in the geologic aspects of engineering. The contractor provided reconnaissance geologic information along a proposed barge canal route following the Gulf coast from St. Marks to the Suwannee River. Under the contract auger holes were drilled to bedrock, or to a depth of 20 feet in overburden, in a series of cross sections normal to the canal center line. Each cross section contained three to five holes at maximum intervals of one-quarter mile. Results were plotted on plan and profile sheets and summarized in a report to the Commission. The report and supporting data were used as basic information in comparing cost estimates for evaluation of the proposed canal.

Field work in connection with many site investigations was of a very preliminary nature. Cursory field inspection to supplement map data was considered sufficient in many cases. Some elevations were determined barometrically and by hand levels. In the case of dam and reservoir projects, cooperating agencies making terminal studies were furnished general guidelines for site investigations. See Section IV—Terminal Studies.

For some sites investigated, much detailed information resulting from studies by other agencies is available. Such information, including reports made by cooperating agencies for other purposes, was used in the study.

After preliminary selection of a site from maps, and such field checks as appeared desirable, the project was further investigated by more detailed office studies. Using a dam and reservoir project as an example of the procedure, the drainage area was first determined by map measurements or from published data. Then areas of the reservoir for a range of pool elevations were determined by planimetering from available contour maps and capacities were computed. Area-capacity curves were drawn and layouts of the principal structures and relocations were made for selected pool elevations.

SECTION II – SITE SELECTION

Some sites were quickly eliminated by an inspection of the layout on a topographic map or by considering available physical data. For example, proposed sites on which dam and reservoir projects would cause extensive flooding of urban land or which are believed or known to be underlain by a cavernous limestone were ordinarily eliminated. Inland navigation projects for which streamflow records indicated that water was not available for normal lock operation or open river navigation were also eliminated.

Some sites which appeared desirable and satisfactory by map inspection and consideration of best available data were later eliminated after a field inspection. This was often because of the inadequacy of the available maps, which either did not show enough detail or were based on outdated surveys. As another example, a proposed fish and wildlife impoundment was eliminated after the field inspection revealed that the site appeared to have more value in its natural state than it would have with the impoundment.

It is possible that some sites which appeared clearly unsatisfactory by map inspection, and were rejected on that basis, would prove feasible upon more detailed inspection. However, the scope of site investigation included allowance for considerable margin of error to take account of such a possibility.

In the final selection of a project site, a cost and benefit comparison was usually the deciding factor, although elimination on this basis could take place at any step in the selection process if excessive costs or meager benefits were clearly apparent at that point.

SECTION III – DESIGN

Project design at each site considered was limited to the detail necessary to demonstrate the possibility of an effective plan of development, to give a reasonable comparison with alternative sites, and to provide a basis for cost estimating.

Cooperating agencies making terminal studies followed the policies and procedural guidelines adopted by the Commission, as stated in Section IV – Terminal Studies. Such detailed design requirements as were considered necessary to attain reasonable uniformity in the studies are also given in Section IV.

Corps of Engineers practice in the Southeast governed design of navigation locks and channels and was also used generally for the larger earth dams, concrete dams, and spillways. Soil Conservation Service standards were used for small impoundments. Recreation facility designs were adapted from recent practice of several agencies, including the Department of Agriculture, the Corps of Engineers, and the National Park Service. Guidelines provided in publications of the National Conference on State Parks were also utilized. The Bureau of Public Roads standards and appropriate State highway standards were used for highways and bridges. In cases where earthfills for highways were to be used also as impoundment structures, the embankments were considered as earth dams and were so designed. Guidelines with respect to engineering design standards for fish and wildlife facilities were obtained from the cooperating State and Federal conservation agencies. These include the Bureau of Sport Fisheries and Wildlife, the Bureau of Commercial Fisheries, and the State game and fish departments of South Carolina, Georgia, Florida and Alabama.

In all project planning design, recognized and proven modern methods conforming to good engineering practice were used. The limited detail of the work necessary to accomplish the desired purpose did not warrant extensive investigations of new and unproved procedures, although novelty alone did not rule out their use.

The typical structures and systems shown on Figures 4.2, 4.3, 4.4, and 4.5 are for general information only and are not drawn to scale.

TYPICAL DAM AND RESERVOIR PROJECT

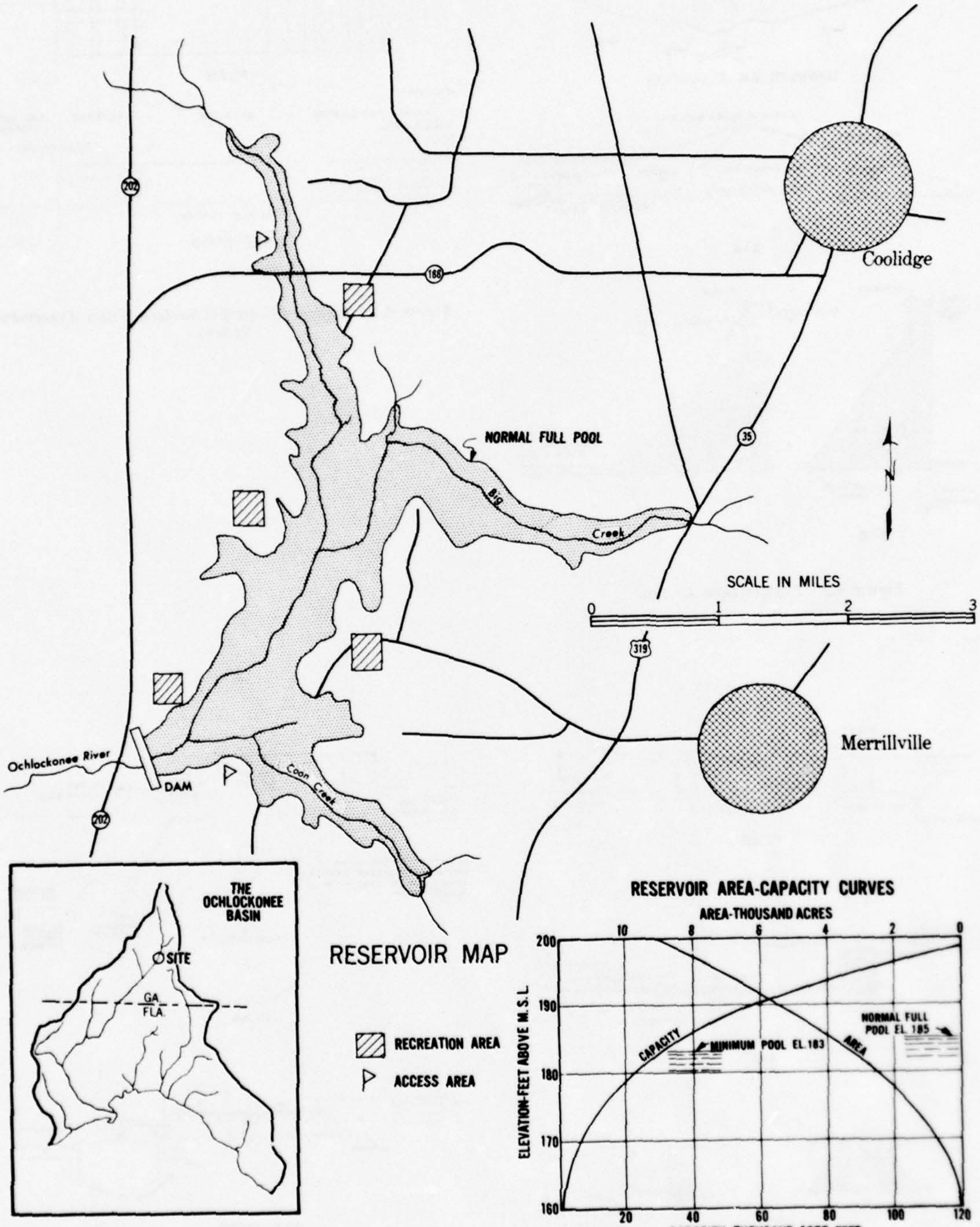


Figure 4.1

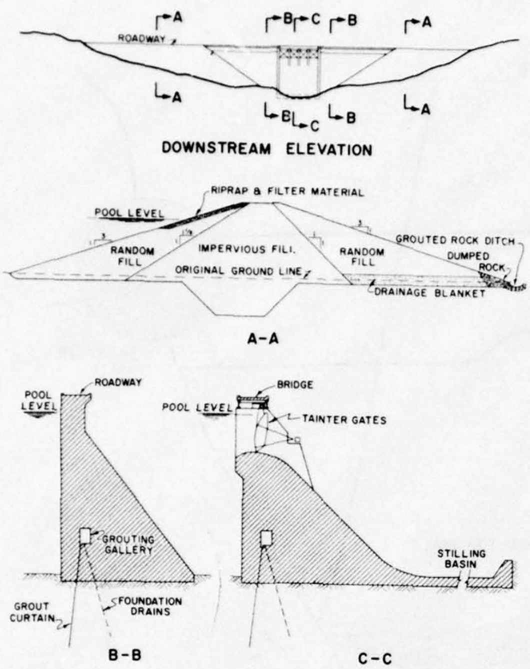


Figure 4.2 *Typical Dam Design.*

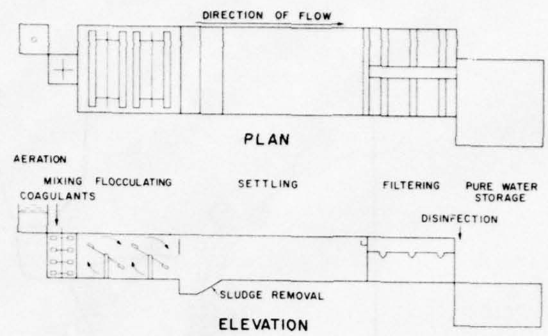


Figure 4.4 *Typical Municipal Surface Water Treatment System.*

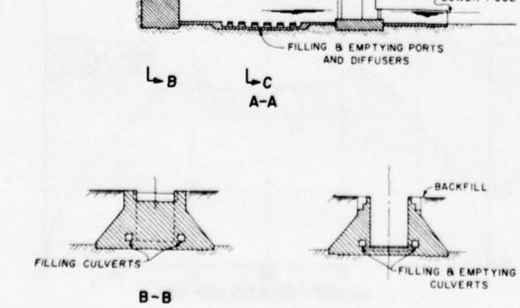


Figure 4.3 *Typical Navigation Lock.*

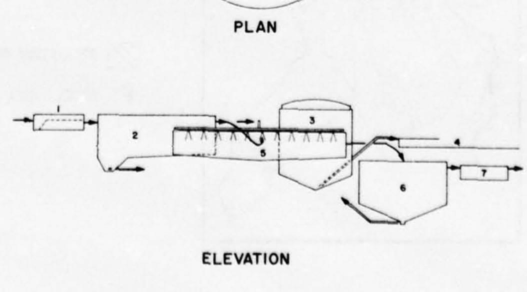


Figure 4.5 *Typical Municipal Sewage Treatment System.*

SECTION IV – TERMINAL STUDIES

The following policies and procedural guidelines were applicable in the order listed for guidance in the planning of projects and programs for resource development:

1. U. S. Study Commission statements of policy.
2. Functional and Basic Work Plans, Technical Supplements, and Work Agreements or contracts and written instructions from the Office of the Executive Director, U. S. Study Commission.
3. Report of the Federal Interagency Committee on Water Resources, "Proposed Practices for Economic Analysis of River Basin Projects," prepared by the Subcommittee on Evaluation Standards, May 1958, commonly referred to as "The Green Book," for economic aspects of planning only.
4. Agreements between agencies having primary interest in the matter under consideration, other than jurisdictional.
5. Manuals or other policy and procedural statements of the cooperating agency.
6. Current practices of the cooperating agency.

A staff section of sufficient size to make all site investigations, preliminary designs, and cost estimates was considered unwarranted. The time period necessary to organize and train such a section would have delayed the studies, and considerable expense would have been involved in acquiring qualified personnel for a comparatively short time. For these reasons agreements were made with existing Federal agencies to perform such work in accordance with guidelines established in work plans and technical supplements for terminal studies.

The U. S. Department of Agriculture, Soil Conservation Service, and the U. S. Army Corps of Engineers were the lead agencies in the terminal studies for multiple-purpose dam and reservoir development and made required site investigations. Cited below are pertinent guidelines, criteria, and detailed requirements excerpted from the technical supplements to a typical work plan for dam and reservoir project investigation by the Corps of Engineers. Studies designated Phase I were preliminary appraisals. Those designated Phase II were studies of sites selected for further investigation as determined from the results of Phase I studies. Designations refer to terminal study phases only and not to phases of the plan.

Phase I

Guidelines and Criteria

1. Inasmuch as all the details are not given, the Corps of Engineers will exercise its best judgment to accomplish the work and to maintain the various parts of the study in relative balance.
2. U. S. Army Map Service and U. S. Geological Survey maps, and any other maps in the files of the Corps of Engineers, will be used to the greatest extent possible in the studies.
3. No subsurface explorations are contemplated for the studies. The use of available geologic and subsurface information is encouraged.
4. Corps of Engineers criteria will be used if no specific provision is applicable from the U. S. Study Commission outline of priorities on policies and procedural guidelines.
5. Consideration will be given to the dual use of proposed roadfills for highway and dam purposes. Such proposed construction should be designed for dam and road use.
6. No surveys will be made at potential dam and reservoir sites where adequate survey data are available. Army Map Service and U. S. Geological maps with contours at intervals of 10 feet or less are considered adequate for study purposes, and these maps may be used unless more detailed maps are available.
7. Cross-section surveys at the damsite and pool elevations at pertinent reservoir points will be made at only those potential dam and reservoir sites where adequate contour maps are unavailable, and which have been approved for survey by the U. S. Study Commission after the sites have been reconnoitered. The survey will be made as outlined in this technical supplement.
8. Up-dated estimates of costs for sites previously studied will include prices and quantities which have been adjusted so that they

represent January 1960 prices and present-day conditions at the site. If new roads, railroads, etc., have been constructed in the reservoir area since the previous study was made, the relocation costs for these facilities will be included in the estimate of cost. Conversely, the costs previously included for relocations or adjustments of roads, railroads, etc., now abandoned will be deleted from the estimate.

Detailed Requirements

1. The location of dam and reservoir sites will be shown on U. S. Geological Survey topographic maps or other suitable maps. In areas covered only by U. S. Geological Survey maps at a scale of 1:250,000 and contours at intervals of 50 feet or more, it will be necessary for staff representatives of the Corps of Engineers to make field reconnaissances to determine the most suitable location for each site.

2. The drainage area above each damsite considered will be determined. Area and capacity curves will be prepared for the sites for which there are suitable maps for this purpose. Data available from previous studies will be used, avoiding duplication of effort.

3. All dam and reservoir sites considered will be reconnoitered with representatives of the U. S. Study Commission and other interested agencies.

4. Estimates of dam and reservoir costs will be prepared for all sites selected for further study by the U. S. Study Commission after the sites have been reconnoitered. A cost curve showing the relationship of dam and reservoir costs to pool elevation for each site selected for further study and including the sites previously studied by other agencies will be prepared.

5. Any unusual costs for a particular site will be explained in the estimate of cost with an explanatory note. An explanation will also be given where there are variations in unit prices for the same items of work at different sites, except where such differences result from variations in quantities only.

6. Appropriate contingencies will be included and identified in the estimate. The value to use will be based on judgment, giving due consideration to the care taken to prepare the estimate and the accuracy of the survey data, maps, and other data used in the study. The cost of engineering and design will be shown as a percentage of the construction costs, including contingencies, and identified. The figure used will be based on experience and cost records of similar projects of comparable size. Engineering costs are considered to include all costs in connection with making detailed dam and reservoir site surveys, subsurface explorations, field hydraulic investigations, model studies if required, and the complete design of the project. The cost of supervision, inspection, and administration will also be given and identified.

7. Real estate will include the cost of the land for the damsite, borrow areas, spoil areas, and reservoir areas. For the purpose of the real estate estimate of cost, the land will be taken in fee to the water surface elevation of the spillway design flood. Real estate costs will include the estimated value of improvements, minerals, water and other rights, severance damages, resettlement, and acquisition costs. Any factor added to the net real estate costs will be identified. The per acre cost of land used and the cost per mile of access roads and utility relocations will be included in the Report.

8. The relocations and improvement costs will be based on plans which conform to the standards of the State and the county where the facilities are located.

9. Data on selected sites previously studied should be up-dated.

10. A cross-section survey will be made of those sites which are approved for further study by the U. S. Study Commission after the sites have been reconnoitered. Data on existing aerial photographs will be utilized to the fullest extent.

11. No horizontal control will be required except as follows:

a. Cross sections will be taken, if possible, on lines which are shown on the photographs.

b. If sections are taken on lines which cannot be identified on the photograph, these section lines will be tied into known points which are shown on the pictures and can be found in the field. The ties may be made by stadia traverse or other comparable means.

12. Vertical control will be based on mean sea level datum.

13. Rough leveling will be adequate in establishing temporary bench marks for cross-sectional work.

14. Barometric leveling may be used in establishing temporary bench marks provided barometric corrections are made.

15. A cross section shall be taken only at the damsite.

16. Cross sections may be taken with the use of transits, levels, tapes, handlevels, or a combination of all these instruments.

17. At sites where field surveys are made, the area and capacity curves may be prepared as follows, in the absence of better methods which might be used, within the limits of time and money:

a. Locate the damsite on a U. S. Geological Survey map.

b. Obtain the elevation, mean sea level, for zero reservoir area and capacity from the cross-section data.

c. Obtain the reservoir area by planimetering the area within the contour lines.

d. Obtain the capacity of the reservoir at the contour elevation by the formula:

[1]$C = 0.4D \times A$ where

C = capacity in acre-feet of storage

D = the height in feet of the contour elevation above the lowest (zero) elevation at the damsite

A = reservoir area in acres at the contour elevation

e. Use log-log paper for the area and capacity curves. Plot the two area points and the two capacity points from data previously obtained. The curves will be straight lines connecting these two points, respectively, and extending to the maximum elevation determined from the cross section at the damsite.

18. Dam design

a. Spillway discharge capacity – to be taken from generalized curves which have already been prepared by the Corps of Engineers.

b. Earth embankment slopes – as selected by Corps of Engineers.

c. Top width of earth embankment – 20 feet.

d. Freeboard – 5 feet.

[1] The factor 0.4 should be checked and modified by the cooperating agency, if required, for more accurate results.

Phase II

Guidelines and Criteria

1. Inasmuch as all the details are not given, the Corps of Engineers will exercise its best judgment to accomplish the work and to maintain the various parts of the study in relative balance.

2. U. S. Army Map Service and U. S. Geological Survey maps, and any other maps in the files of the Corps of Engineers, will be used to the greatest extent possible in the studies.

3. Corps of Engineers criteria will be used if no specific provision is applicable from U. S. Study Commission outline of priorities on policies and procedural guidelines.

4. Subsurface explorations are not contemplated for the studies and no subsurface explorations for these studies will be made at any site unless approved in writing by the U. S. Study Commission.

5. Topographic surveys at potential dam and reservoir sites are not contemplated and no surveys will be made for these studies at any site unless approved in writing by the U. S. Study Commission. Surveys made for Phase I studies and existing maps will be utilized.

6. A copy of the essential data contained in reports made by the Soil Conservation Service covering Phase I studies of potential dam and reservoir sites to be studied under this technical supplement will be furnished to the Corps of Engineers by the U. S. Study Commission.

7. The reservoir areas, for reservoirs with depths of 60 feet or less below the normal full pool at the dam, will normally be completely cleared to a line 2 feet above the normal full pool elevation. The reservoir areas, for reservoirs with depths greater than 60 feet below the normal full pool at the dam, will normally be cleared from a line 2 feet above the normal full pool elevation to a line at a depth of 5 feet below the minimum pool elevation and at this depth for the remainder of the reservoir area. If areas are to be left uncleared at specific sites, such areas will be delineated by the U. S. Study Commission.

Detailed Requirements

1. Dam and Reservoir Design

a. The type of dam and spillway will be selected by the Corps of Engineers.

b. The spillway design-discharge capacity will be determined by use of curves prepared by the U. S. Study Commission entitled "Curves for Estimating Spillway Capacities in Coastal Plain, or Blue Ridge and Piedmont, for Terminal Studies of Dams and Reservoirs" dated June 30, 1961.

c. The Corps of Engineers will determine the size and types of outlet works required. The details of design will be only to the extent needed for determining the approximate cost of the outlet works.

2. Project First Costs

a. The estimated cost will be prepared for each project covered by this technical supplement. Included in the project cost will be the component costs of the project which were prepared by other agencies. The cost of an access road to the dam will be part of the dam and reservoir costs. Roads to serve recreation areas and for other functional purposes will be included in the costs of works they serve. The cost for the hydroelectric power facilities, fish and wildlife, recreation, and other functional facilities located adjacent to the reservoir will be shown separately for each function.

b. Any unusual costs for a particular site will be explained in the estimate of cost with an explanatory note. An explanation will also be given where there are variations in unit prices for the same items of work at different sites, except where such differences result from variations in quantities only.

c. Appropriate contingencies will be included and identified in the estimate. The value to use will be based on judgment of the cooperating agency, giving due consideration to the care taken to prepare the estimate and the accuracy of the survey data, maps, and other data used in the study. The cost of engineering and design will be shown as a percentage of the construction costs, including contingencies, and identified. The figure used will be based on experience and cost records of similar projects of comparable size. Engineering costs are considered to include all costs in connection with making detailed dam and reservoir site surveys, subsurface explorations, field hydraulic investigations, model studies, if required, and the complete design of the project. The cost of supervision, inspection, and administration will also be given and identified.

d. Real estate costs will include the cost of the land for the damsite, borrow areas, spoil areas, and reservoir areas. For the purpose of the real estate estimate of cost, the land will be taken in fee to the water surface elevation of the spillway design flood. The costs for real estate above the design flood needed for recreation and other purposes will be included in the estimated costs for these facilities. Real estate costs will include the estimated value of improvements, minerals, water and other rights, severance damages, resettlement, and acquisition costs. Any factor added to the net real estate costs will be identified. The per acre cost of land used and the cost per mile of access roads and utility relocations will be included in the report.

e. The relocations and improvement costs will be based on plans which conform to the standards of the State and the county where the facilities are located.

3. Price Levels

Price levels prevailing during an appropriate period ending approximately January 1960 will be used for evaluating all costs and benefits.

4. Investment Costs

The investment cost for each project is equal to the first cost plus interest on the total first cost for half of the construction period. Interest for construction periods of 2 years or less will be disregarded.

5. Interest Rates

The following interest rates will be used in studies of project investment, evaluation, allocation of costs, and cost sharing:

For Federal resource financing	2⅝ percent
For non-Federal financing	4¼ percent

6. Annual Costs

a. Annual costs will be computed on the basis of the appropriate annual interest rate with amortization of the project investment over the estimated economic life of the project. Included in the annual costs will be the estimated allowances for operation and maintenance of the project and for replacement costs.

b. The economic evaluation will be based on a maximum project life of 50 years.

PART FIVE – COST ESTIMATING

SECTION I – GENERAL

This Part of Appendix 11 is concerned with monetary values for construction or development costs and for annual operation, maintenance, and replacements costs.

The designs and estimates are refined to only that degree of precision necessary (1) to determine whether, by comparison of costs and benefits, a project being investigated could reasonably be included in the plan; and (2) for comparison of alternatives to determine which projects should be included.

Prices prevailing during an appropriate period ending approximately January 1960 were used for evaluating costs and benefits. However, agricultural prices paid were adjusted to current, 1960, price levels with further adjustment of items within these price levels to reflect expected future relationships among them. In effect, all nonagricultural costs and average costs of producing each of the various agricultural crops used were those prevailing about January 1960, with an adjustment of agricultural prices paid and prices received based on an assumed parity ratio of 89.

SECTION II – PROJECT COSTS

The total investment in a construction project, exclusive of pre-authorization planning costs, includes the costs of land and clearing; construction items such as relocations, excavation, concrete, structural steel, and the furnishing and installing of equipment; engineering and design; supervision, inspection and administration; and interest on the foregoing items during construction. To the subtotal of land and construction costs is added an allowance for contingencies, the remaining items being computed as percentages of the new subtotal.

For most construction project estimates a 25-percent contingency allowance was used. This compares with Corps of Engineers practice of 20-percent contingency allowance for the survey stage of investigation for projects in this area estimated to cost less than $7½ million. Some estimated construction costs were based on actual contract costs for similar work. In such cases no contingency item was added. Also, some agencies provided only total costs, without a breakdown to show contingencies, engineering, design, supervision, inspection, and overhead. Estimates based on such data were used without adjustment if the allowances appeared to be consistent with those used for other projects with a similar degree of precision in background data and design.

Cost data in many forms were received from many agencies, Federal, State, and private, and were adapted for use in estimating project costs. The sources listed below supplied cost data on the items noted.

Federal Agencies

Public Health Service:
- Domestic water supply, wells and equipment
- Municipal water supply, wells and equipment
- Municipal water supply, surface source pumping facilities
- Municipal water supply, treatment plants
- Municipal water supply, elevated storage
- Water distribution systems
- Sewage treatment plants
- Sewerage systems
- Sanitary landfills
- Operation and maintenance
- Service life

Bureau of Reclamation:
- Hydroelectric plants
- Pumping stations
- Transmission lines
- Operation and maintenance
- Service life

(continued)

Federal Agencies – *Continued*

Bureau of Sport Fisheries and Wildlife:
- Boat ramps
- Fish hatcheries
- Water control structures
- Parking areas
- Large impoundments
- Small impoundments
- Roads and trails
- Operation and maintenance
- Administration and service

National Park Service:
- Recreation facilities, such as campsites, boathouses, trails, boat ramps, and piers
- Sanitary facilities
- Water supply
- Roads
- Parking areas
- Administration facilities such as headquarters buildings, and grounds, entrance booths, markers, and general landscaping
- Operation, maintenance, and replacements

U. S. Forest Service:
- Roads and trails
- Fire control
- Tree planting
- Timber-stand improvement
- Management
- Grazing control
- Research facilities
- Watershed protection
- Administration facilities
- Administration
- Operation, maintenance, and replacements

Soil Conservation Service:
- Floodwater retarding structures
- Channel improvement
- Farm ponds
- Outlets
- Recurring and enduring type conservation practices
- Drainage
- Operation and maintenance
- Engineering services
- Administration

Corps of Engineers, U. S. Army:
- Land
- Clearing
- Reservoirs
- Relocations
- Channel work
- Canals
- Navigation locks
- Dams (concrete and earth)
- Pumping stations
- Levees
- Powerplants
- Harbor work
- Access roads
- Outlet works
- Spillway and appurtenances
- Forest roads and trails
- Forest fire control
- Tree planting
- Timbershed improvement
- Forest management
- Operation, maintenance, and replacements
- Service life
- Contingency allowances
- Engineering and design
- Supervision, administration, and inspection

Bureau of Public Roads:
- Highways
- Bridges
- Maintenance

Federal Power Commission:
- Hydroelectric plants, construction costs
- Hydroelectric plants, operation and maintenance costs

State Agencies

Georgia Ports Authority:
- Harbor facilities
- Operation and maintenance

Auburn University:
- Land clearing

Forest Services:
- Forest fire control

(continued)

State Agencies – Continued

Game and Fish Departments of South Carolina, Georgia, Florida, and Alabama:
- Boat ramps
- Parking areas
- Fish hatcheries
- Game farms
- Large impoundments
- Small impoundments
- Fishing reefs
- Fishing piers

Highway Departments of North Carolina, South Carolina, Georgia, Florida, and Alabama:
- Highways
- Bridges
- Grade separations
- Culverts
- Maintenance
- Service life

Other Sources

Southern Railway System:
- Railroads
- Bridges
- Grade separations
- Maintenance
- Service life

Engineering handbooks, periodicals, and other publications:
- Costs of miscellaneous items
- Operation and maintenance
- Service life
- Cost indexes

Southern Bell Telephone and Telegraph Company:
- Pole lines
- Maintenance
- Service life

Plantation Pipeline Company:
- Petroleum pipelines
- Petroleum pumping stations
- Petroleum storage tanks
- Petroleum metering equipment
- Operation and maintenance
- Service life

Southern Natural Gas Company:
- Gas pipelines
- Compressor stations
- Metering and regulating stations
- Operation and maintenance
- Service life

The service life of project components is important because of the direct bearing on replacement costs. Although it may be contended that a component with a longer service life than the economic life of the project of which it is a part is not justified, this is not necessarily the case, because of the cheaper maintenance and more nearly trouble-free operation that usually characterizes long-lived units. The period of analysis was established as the economic life of each project or program on the basis of individual case study. An assumed economic life longer than 50 years was provided for when warranted. However, a maximum of 50 years was used in the studies, although annual costs figured on that basis may be conservatively high in many cases.

Service lives of project components such as spillway gates for dams and equipment for ground water supply installations have been estimated as an aid in determining the annual costs over the period of analysis of the project.

Cooperating agencies furnished cost estimates in technical memoranda in connection with single-purpose studies. These are generally of a very preliminary nature and for the purpose of judging whether or not a project is economically feasible as a single-purpose development, or which of several schemes or locations will best serve the purpose, considering cost and other factors.

A further step in planning, the terminal studies, was also undertaken by cooperating agencies under agreement with the Commission. Under these agreements these studies were to include selection of the most desirable projects and preparation of estimates of investment and annual costs and allocation of these costs to the purposes served by multiple-purpose projects.

After the terminal studies for the first two basins were well underway, it was possible to handle the administrative details of the cooperative arrangements on a less formal basis than was first contemplated. This expedited the work and provided greater flexibility in making adjustments in the plans as they were developed.

ENGINEERING AND DESIGN COSTS

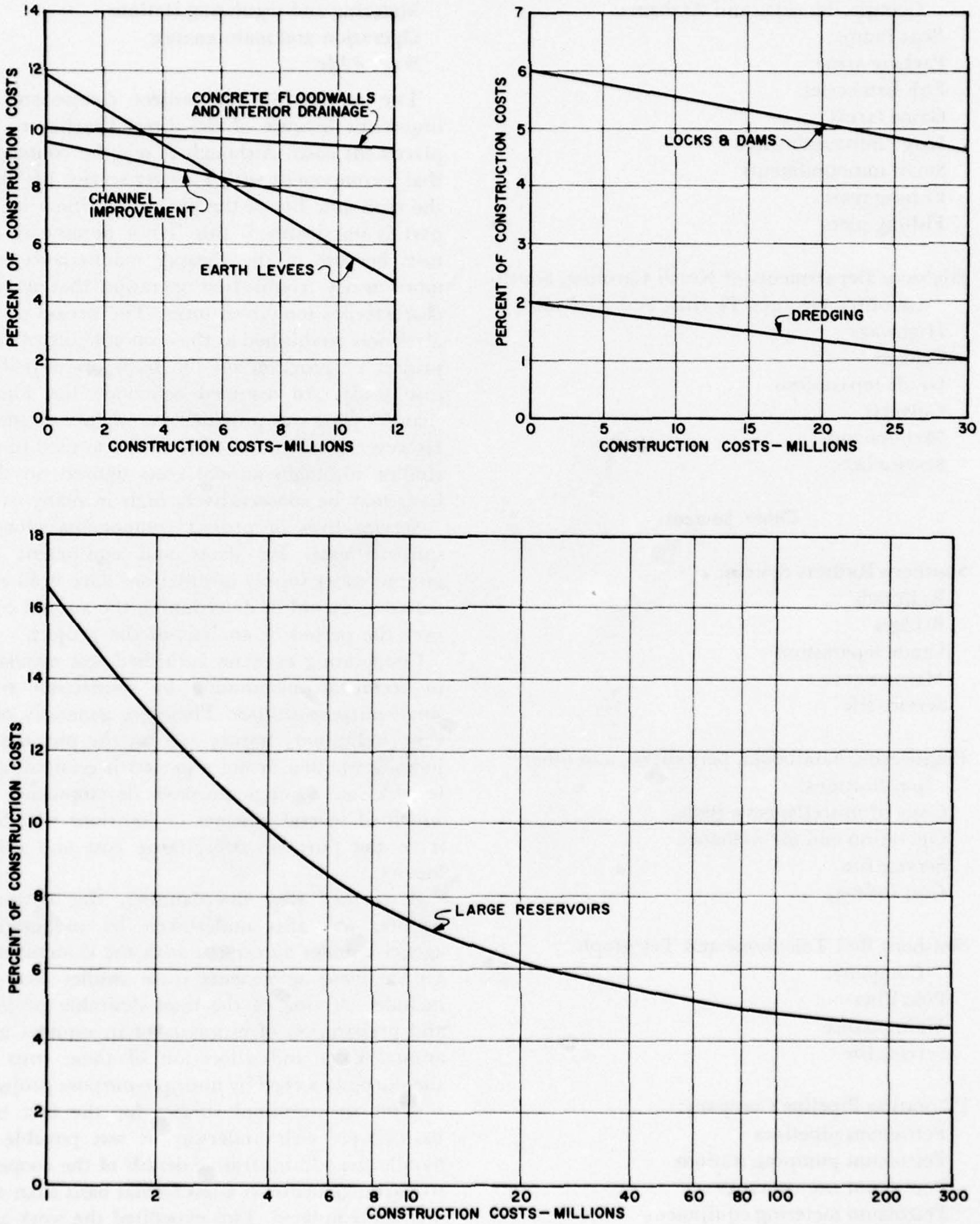
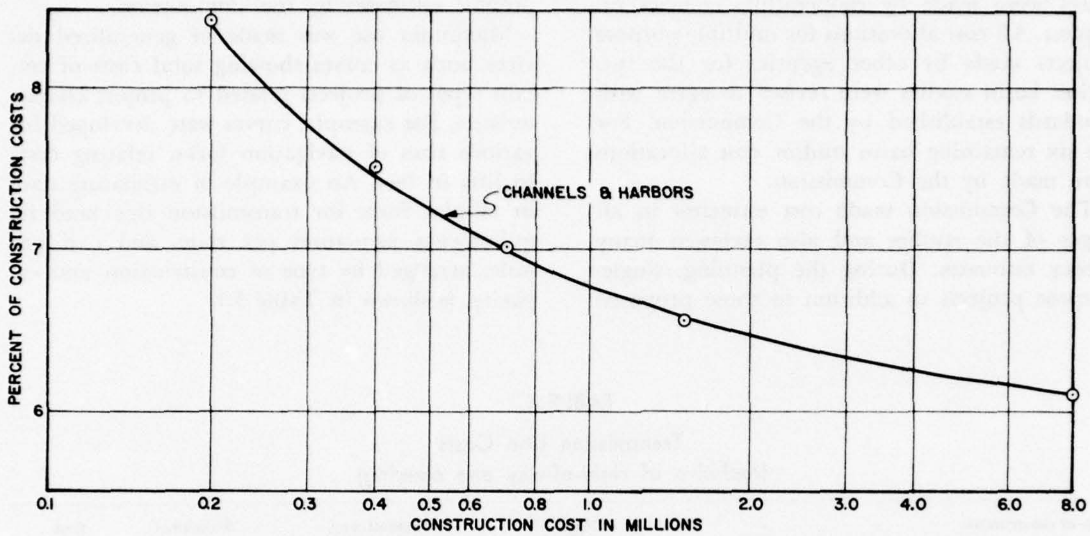


Figure 5.1

SUPERVISION, INSPECTION AND ADMINISTRATION COSTS



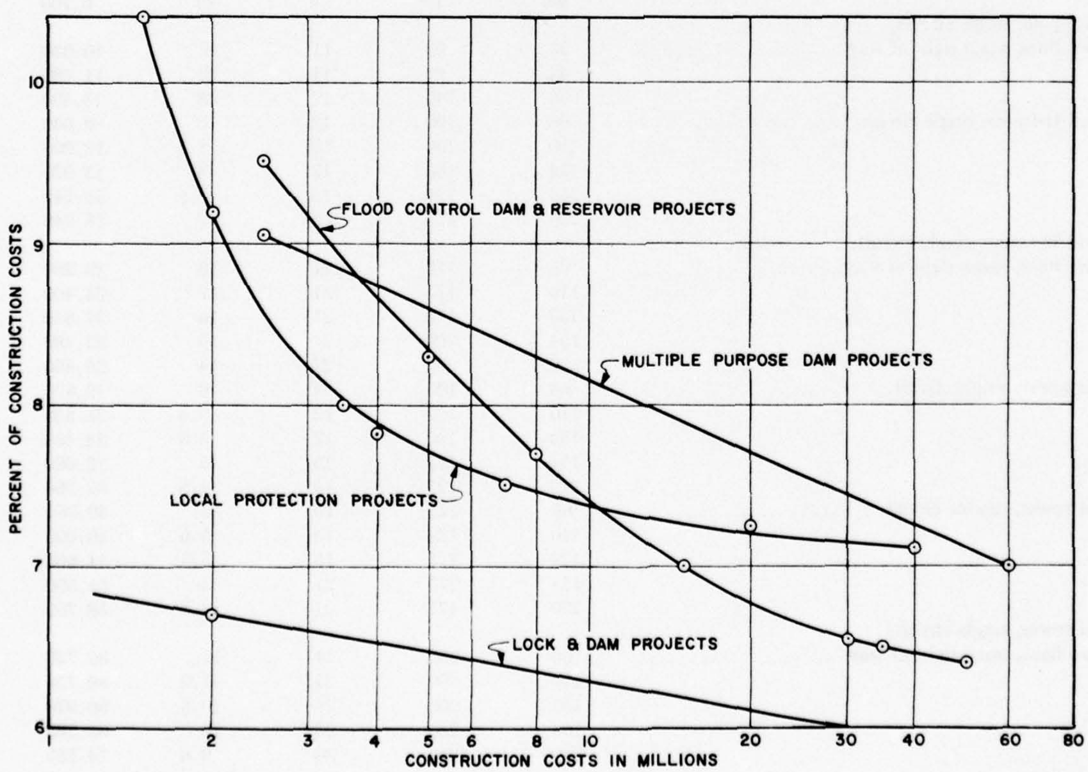


Figure 5.2

In many cases reconnaissance and preliminary studies were made by the Commission and estimates were made by cooperating agencies on request. All cost allocations for multiple-purpose projects made by other agencies for the two earlier basin studies were revised to agree with standards established by the Commission. For the six remaining basin studies, cost allocations were made by the Commission.

The Commission made cost estimates in all stages of the studies and also reviewed many agency estimates. During the planning, single-purpose projects in addition to those proposed in the technical memoranda as well as additional alternatives were often investigated, necessitating prompt estimates by the Commission.

Maximum use was made of generalized devices, such as curves showing total costs of certain types of projects related to project characteristics. For example, curves were developed for various sizes of navigation locks, relating costs to lifts in feet. An example of estimating data in tabular form for transmission line land requirements, structures per mile, and cost per mile, arranged by type of construction and capacity, is shown in Table 5.1.

TABLE 5.1

Transmission Line Costs
(exclusive of right-of-way and clearing)

Type of construction	Nominal voltage (kilovolt)	Right-of-way		Structures per mile	Cost per mile
		Width (foot)	Acres per mile		
Wood pole, single circuit	33	50	6	21	$5,040
	44	50	6	20	5,740
	66	75	9	19	6,760
Wood pole, single circuit, two lines, same right of way	33	90	11	42	10,080
	44	90	11	40	11,480
	66	140	17	38	13,520
Wood H-frame, single circuit	66	100	12	9	9,640
	110	100	12	8.5	12,200
	132	100	12	8	13,920
	154	125	15	7.5	16,240
	220	125	15	7	18,240
Wood H-frame, single circuit, two lines, same right of way	66	175	21	18	19,280
	110	175	21	17	24,400
	132	175	21	16	27,840
	154	200	24	15	32,480
	220	200	24	14	36,480
Steel tower, single circuit	66	100	12	6	19,860
	110	100	12	5.6	24,850
	132	100	12	5.3	28,460
	154	125	15	5	32,680
	220	125	15	4.8	37,280
Steel tower, double circuit	66	125	15	6	30,380
	110	125	15	5.6	40,600
	132	125	15	5.3	44,600
	154	175	21	5	51,500
	220	175	21	4.8	58,700
Steel tower, single circuit, two lines, same right of way	66	200	24	12	39,720
	110	200	24	11.2	49,700
	132	200	24	10.6	56,920
	154	250	30	10	65,360
	220	250	30	9.6	74,560

Price indexes, particularly those published weekly and summarized quarterly by Engineering News-Record, were utilized extensively as an aid in converting costs of projects or project components constructed in years prior to or after January 1960 to the January 1960 price level. The index comparisons published by the Office of Business Economics and the Business and Defense Services Administration, both agencies of the U. S. Department of Commerce, were also useful.

Abstracts of bids on Corps of Engineers projects for which contracts were awarded within a period of a year or two prior to January 1960 were used as aids in estimating unit costs of construction items for similar work.

Judgment factors were important in estimating items of investment costs. Among the conditions which affect unit construction costs are the size of the job, the ease or difficulty of construction, the quantities of individual items, the location of the project, the availability and market price of materials and labor, the competition for contracts, and sometimes the financial situation of the successful bidder, which may cause him to bid high on one or more items which can be completed early in the construction period and compensatingly low on one or more of those to be completed later. Obviously, not all of these circumstances can be foreseen in preparing preliminary estimates. Those which were known and which clearly would affect overall costs were taken into account.

Price indexes are reliable only to the extent that the combination of work and material items on which the index is based resembles the main items in the project being considered. Thus the Engineering News-Record Construction Cost Index becomes less reliable when applied to projects involving a large proportion of machinery or of skilled labor, since neither of these items is used in establishing it. Therefore, judgment was applied when using this index.

Figure 5.4 shows investment costs of dam and reservoir projects by reservoir area for each of the eight basins. The points shown on the charts include both estimated costs of considered and proposed projects and actual costs of existing projects adjusted to the January 1960 price level. Power facilities are not included. Basin numbers indicated are as follows:

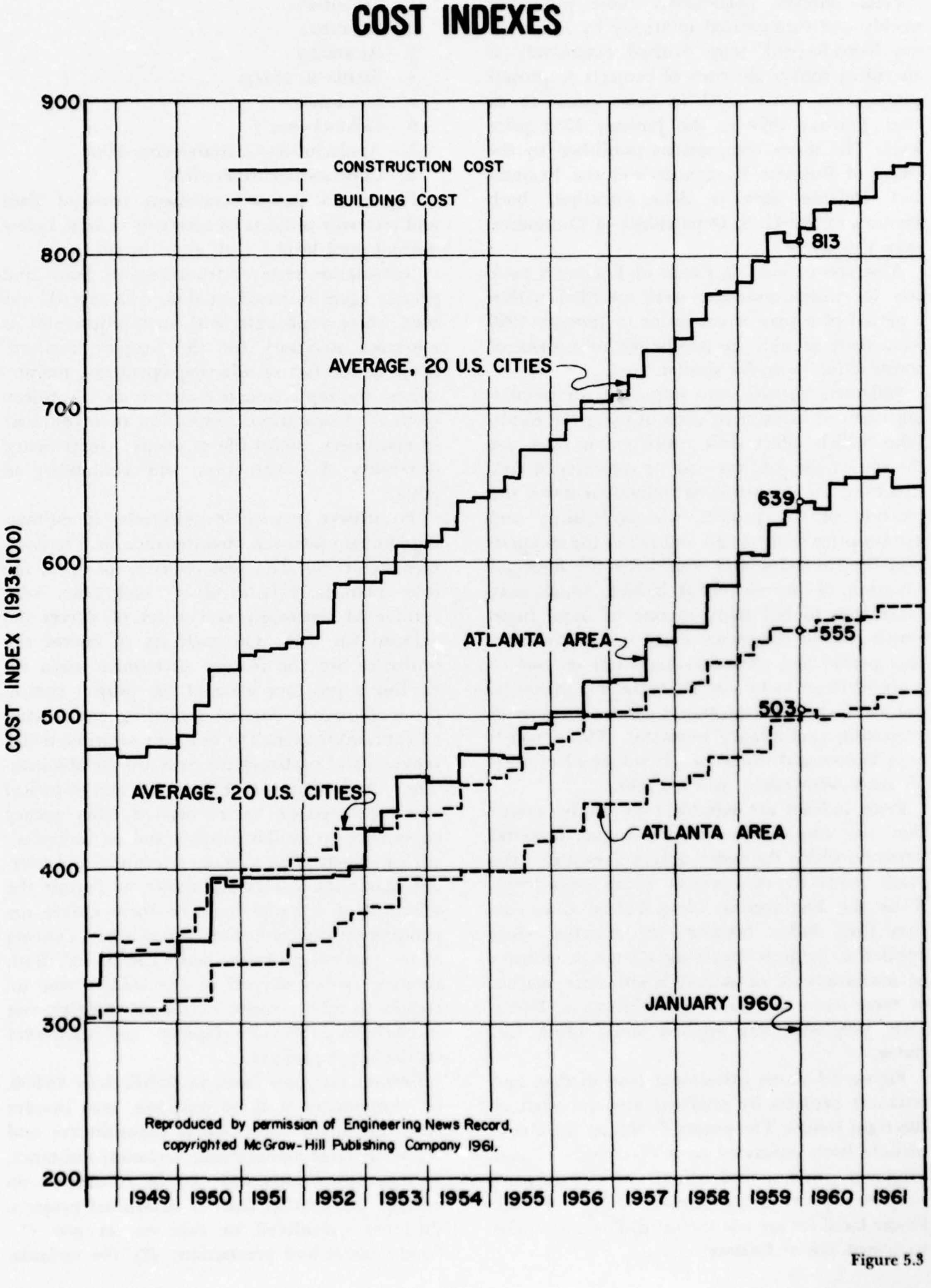
1. Savannah
2. Ogeechee
3. Altamaha
4. Satilla-St. Marys
5. Suwannee
6. Ochlockonee
7. Apalachicola-Chattahoochee-Flint
8. Choctawhatchee-Perdido

Figure 5.5 shows investment costs of dam and reservoir projects by reservoir volume below normal pool level for all eight basins.

Information received from Federal, State, and private agencies based on their own records was used where applicable, with such adjustment as appeared necessary for the project involved. Some of the factors affecting operation, maintenance, and replacements costs are size of project, method of operation, proportion of investment in machinery, useful life of project components, durability of construction, and availability of labor.

To achieve reasonable uniformity in estimating annual operation, maintenance, and replacements costs for dam and reservoir projects, the four main features involving such costs were considered separately and a set of curves developed for each. On each set of curves the ordinates are the feature investment costs including a pro rata share of the project contingency allowance but not including engineering and administration. The annual operation, maintenance, and replacements costs are the abscissae. The curves shown in Figure 5.7 are empirical and are based on values derived from agency experience on similar projects and on independent judgment. The average minimum and average maximum curves are shown to permit the selection of a value between these curves depending on interpretation of conditions existing at the particular project being considered. Both limiting curves steepen as the feature cost increases to take account of the normal increase in efficiency in use of equipment and manpower on the larger projects.

Certain purposes listed in Public Law 85-850, or components of those purposes, may involve relatively small construction expenditures and relatively large management, technical assistance, or supervisory costs and may be considered on an area basis rather than as individual projects. Purposes considered in this respect are (1) flood control and prevention; (2) the reclama-


COST INDEXES
CONSTRUCTION COST
BUILDING COST
900
800
700
600
500
400
300
200
COST INDEX (1913=100)
813
AVERAGE, 20 U.S. CITIES
639
ATLANTA AREA
555
503
AVERAGE, 20 U.S. CITIES
ATLANTA AREA
JANUARY 1960
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1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961

Figure 5.3

DAM AND RESERVOIR INVESTMENT COSTS

BY RESERVOIR AREAS

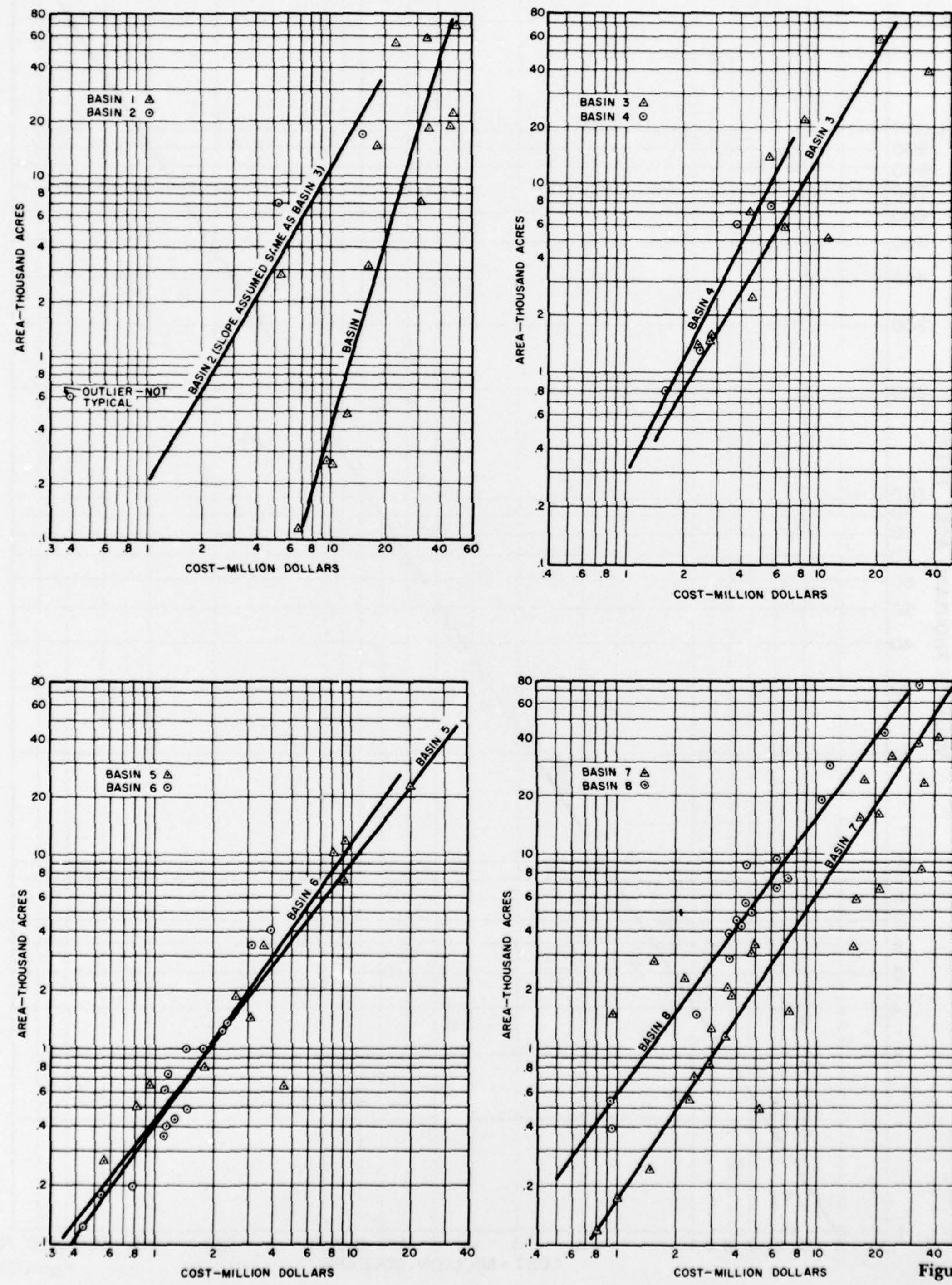


Figure 5.4

DAM AND RESERVOIR INVESTMENT COSTS
BY RESERVOIR VOLUMES

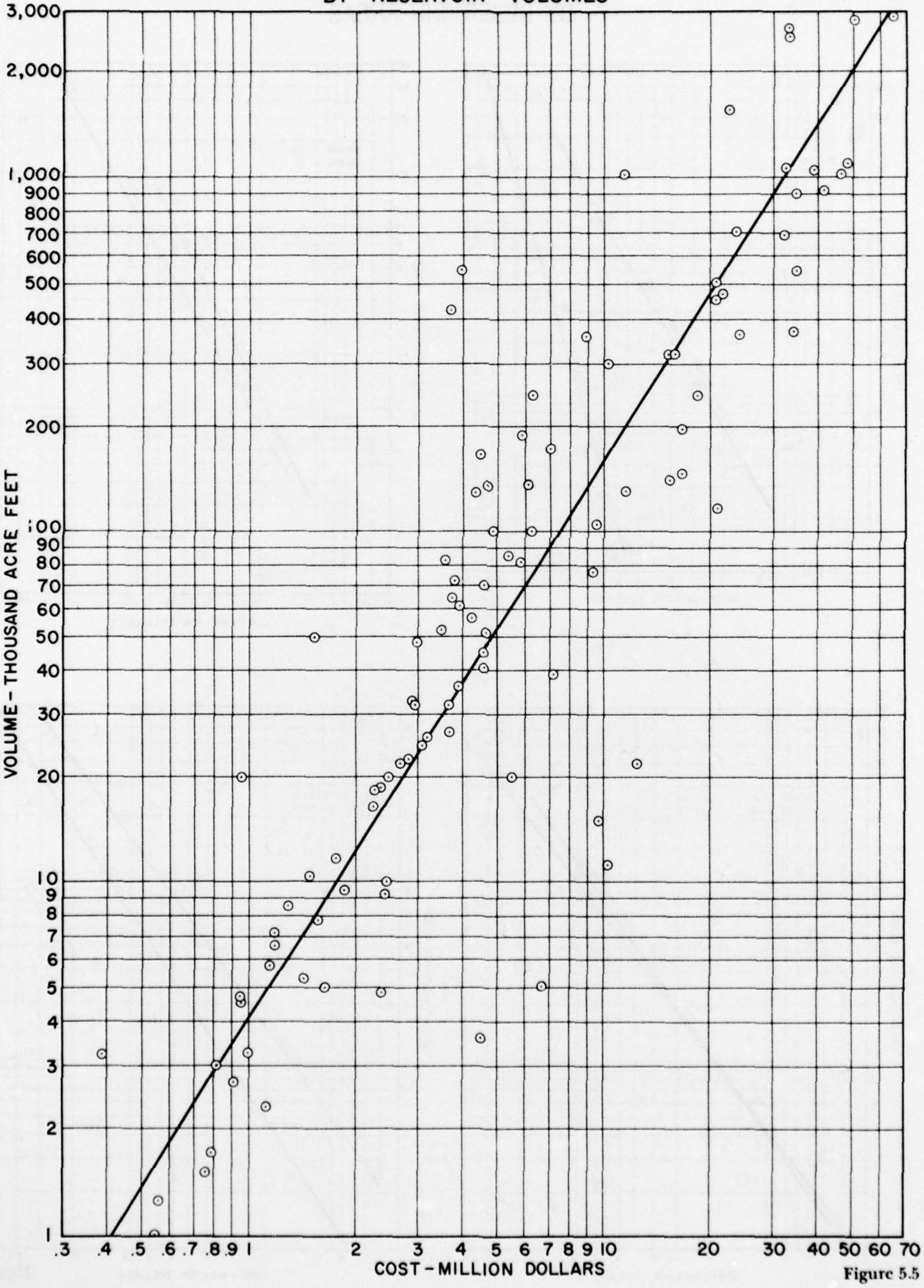
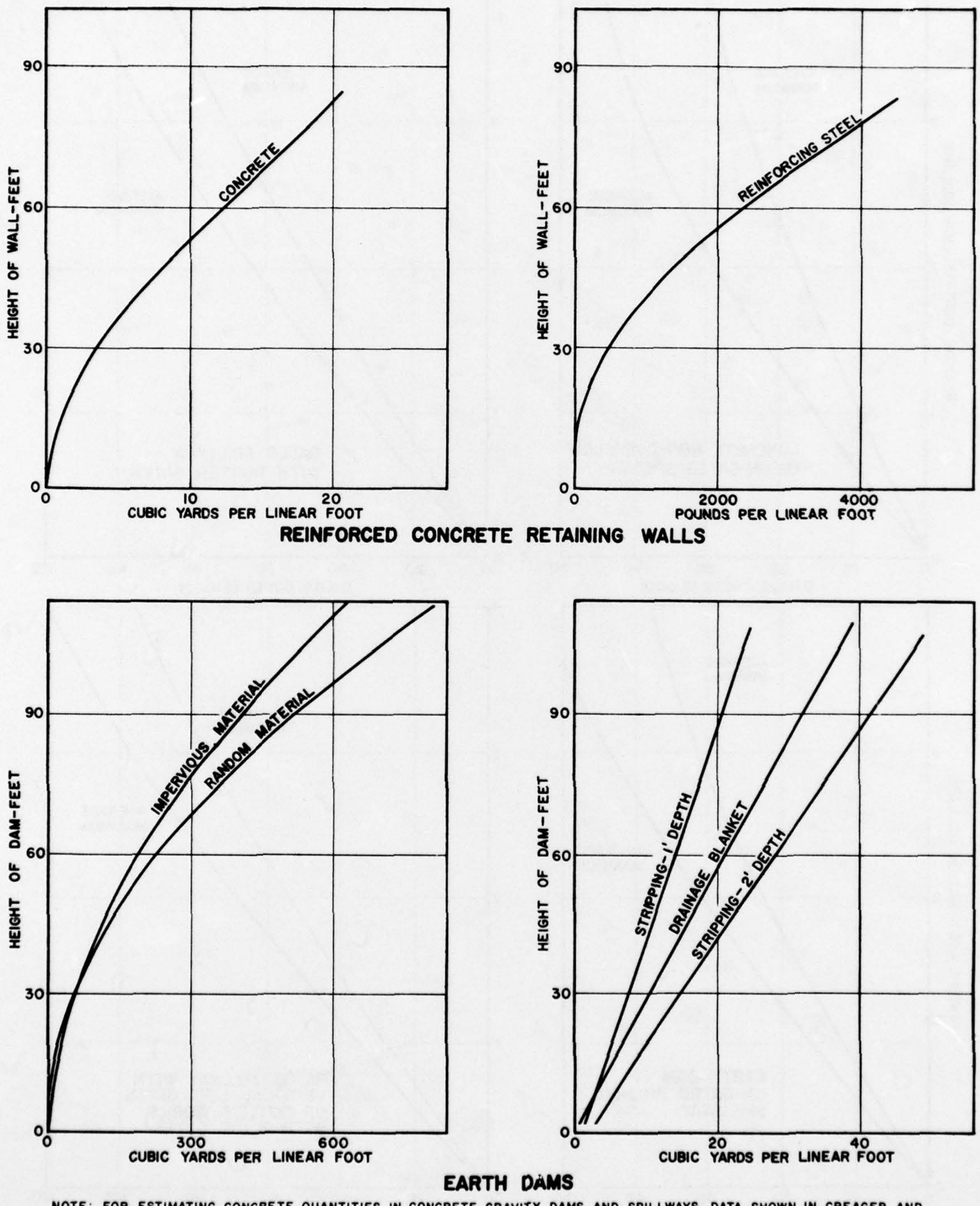


Figure 5.5

CONSTRUCTION QUANTITIES
DAMS AND RETAINING WALLS



EARTH DAMS

NOTE: FOR ESTIMATING CONCRETE QUANTITIES IN CONCRETE GRAVITY DAMS AND SPILLWAYS, DATA SHOWN IN CREAGER AND JUSTIN'S HYDRO-ELECTRIC HANDBOOK, 2nd EDITION, PP. 361 AND 371, WERE USED.

Figure 5.6

DAMS AND RESERVOIRS

ANNUAL OPERATION, MAINTENANCE AND REPLACEMENTS COSTS

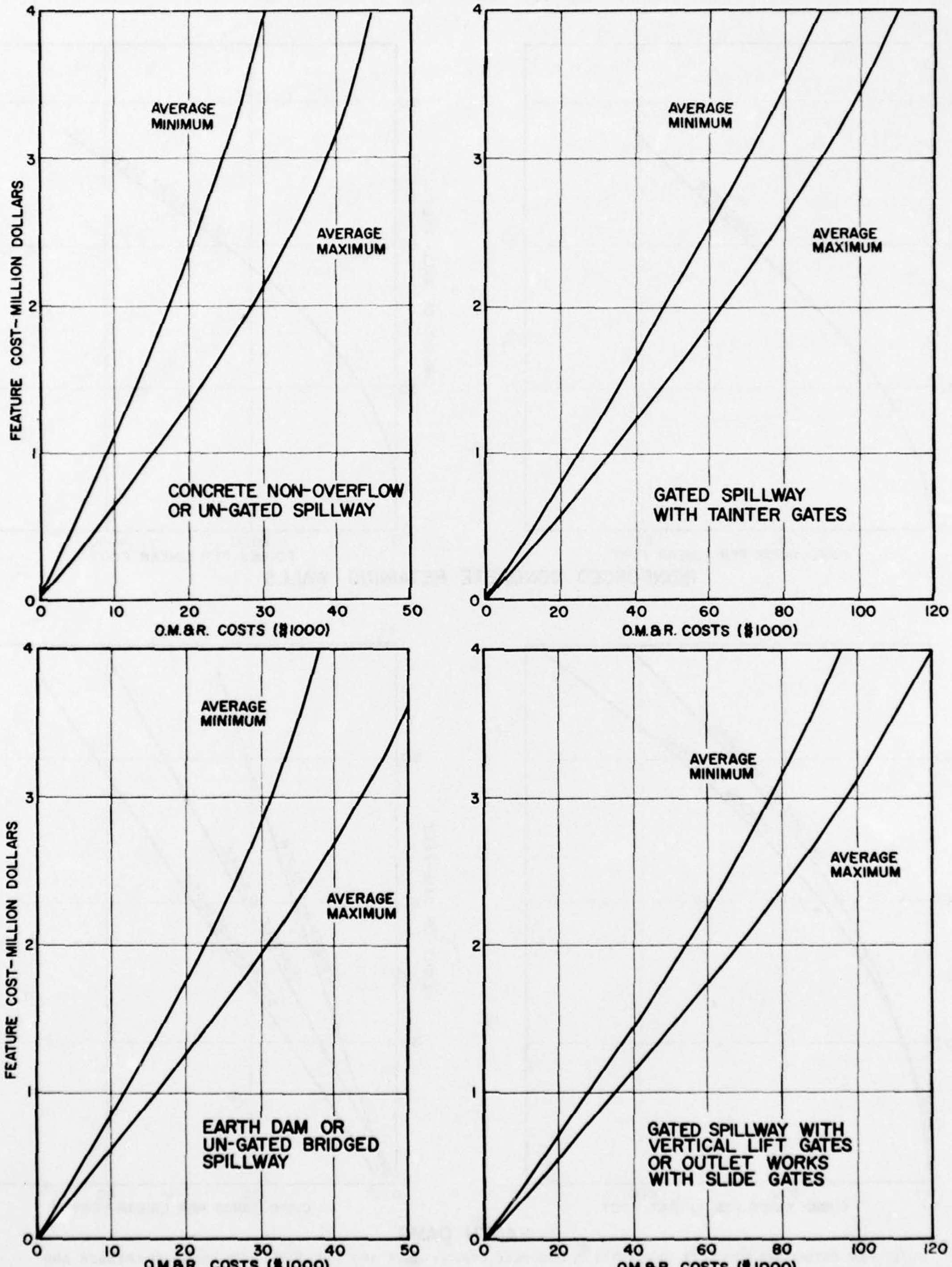


Figure 5.7

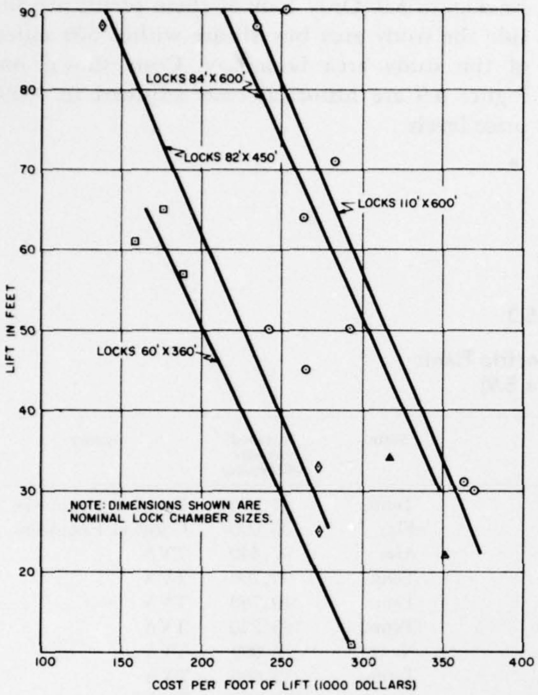


Figure 5.8 *Navigation Locks, Investment Costs.*

tion and irrigation of land, including drainage; (3) soil conservation and utilization; (4) forest conservation and utilization; (5) preservation, protection and enhancement of fish and wildlife resources; and (6) the development of recreation. Large construction projects for any purpose were considered individually rather than in the category defined above. Examples are a large flood control dam or a large and costly recreation development in a specific location.

Costs of facilities for purposes numbered (2) and (3) above and the portion of number (1) which involves small upstream watershed projects were estimated on an area rather than an individual basis. They may comprise a significant amount of construction for small individual projects but their costs were averaged over the large land areas involved.

A variety of activities is included under recreation as considered in the Report. These are sightseeing, outdoor cultural pursuits, picnicking, swimming, hiking, camping, and boating. Costs of providing facilities for these activities have been estimated and expressed in dollars per person capacity. The design capacity is determined by first assigning a percentage of the estimated total annual user-days for a recreation area to each activity to be included in the area. The annual activity days thus established are then multiplied by an empirical design capacity factor based on experience records, giving the capacity requirements for a typical high-use day and providing the basis for facility cost estimates. In addition to the activity costs, certain common use facilities must be considered and their costs used where applicable. These facilities and the unit costs used are:

Parking – $50.00 per person capacity
Water supply – $25.00 per person capacity
Sanitary facilities – $50.00 per person capacity
Roads: (American Association of State Highway Officials Classification)
Class E – (200 vehicles per day, maximum) $44,400 per mile average
Class G – (50 vehicles per day, maximum) $19,600 per mile average
Administrative facilities – $0.05 per annual activity day

The total cost of any recreation facility is the sum of the activity costs and the applicable common use facility costs.

TABLE 5.2

Forestry Costs

Measure	Unit costs
Forest fire protection	Based on State reports
Fencing for grazing control	$300 per mile
Planting for erosion control	$25 per acre
Planting without site preparation	$14 per acre
Planting with site preparation	$28 per acre
Site preparation for natural reproduction	$5 per acre
Noncommercial thinning and deadening	$8 per acre
Shelterbelts	$15 per acre
Technical assistance[1]	$10,000 per man-year
Drainage, including roads	$12 per acre
Research[2]	$15,000 per man-year
Insect and disease control[2]	$15,000 per man-year
Information and education[2]	$10,000 per man-year

NOTES: [1] Includes allowance for travel, office space, and overhead. An additional $2,200 should be allowed for first year equipment cost.
[2] Includes associated costs such as clerical services.

Forestry measures and unit costs adopted are listed below. Management and installation costs for specific areas on Federal lands are supplied by agencies administering those lands.

Table 5.3 lists federally owned hydroelectric plants corresponding to the numbered points on Figure 5.9. Only four of these plants are inside the study area but all are within 300 miles of the study area boundary. Costs shown on Figure 5.9 are historical costs adjusted to 1959 price levels.

TABLE 5.3

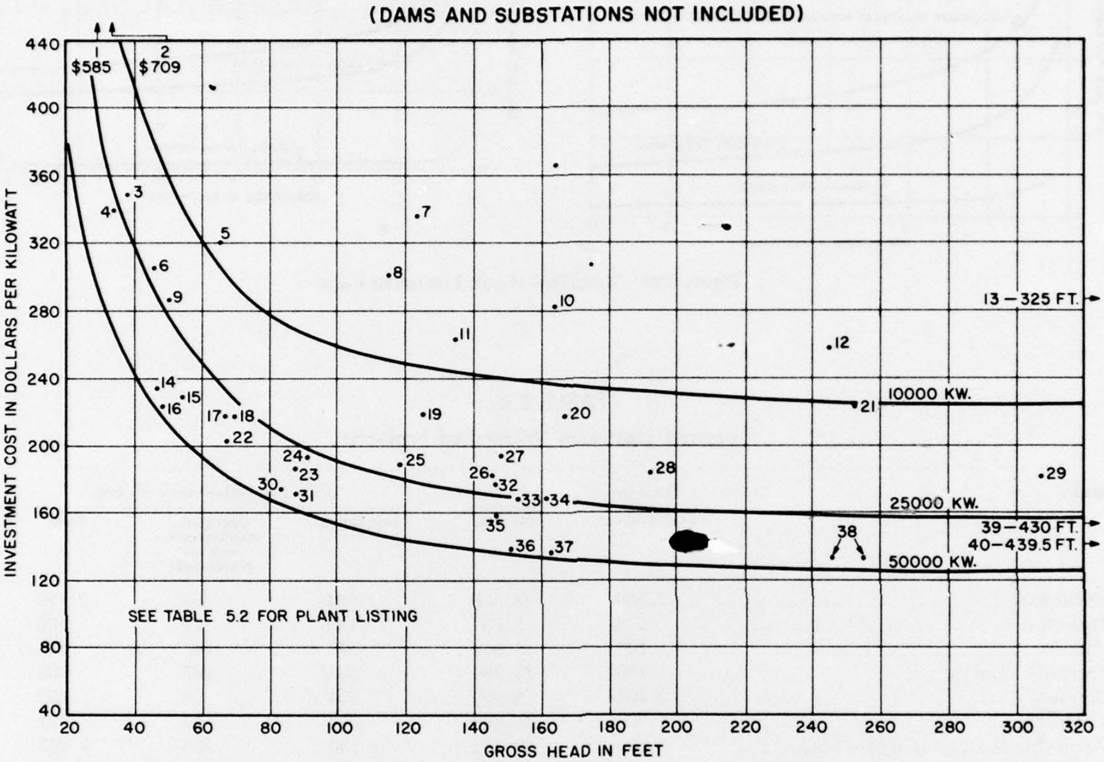
Federal Hydroelectric Plants
(See Figure 5.9)

No.	Plant name	River	State	Installed capacity (kilowatts)	Agency
1	Cheatham	Cumberland	Tenn.	24,000	Corps of Engineers
2	Jim Woodruff	Apalachicola	Fla.	30,000	Corps of Engineers
3	Guntersville	Tennessee	Ala.	97,440	TVA
4	Hales Bar	Tennessee	Tenn.	99,700	TVA
5	Wilbur	Watauga	Tenn.	10,700	TVA
6	Chickamauga	Tennessee	Tenn.	108,240	TVA
7	Chatuge	Hiwassee	N. C.	10,000	TVA
8	Ocoee No. 1	Ocoee	Tenn.	18,000	TVA
9	Kentucky	Tennessee	Ky.	160,320	TVA
10	Philpott	Smith	Va.	14,000	Corps of Engineers
11	Dale Hollow	Obey	Tenn.	54,600	Corps of Engineers
12	Ocoee No. 2	Ocoee	Tenn.	21,000	TVA
13	Watauga	Watauga	Tenn.	50,000	TVA
14	Pickwick Landing	Tennessee	Tenn.	216,320	TVA
15	Watts Bar	Tennessee	Tenn.	150,240	TVA
16	Wheeler	Tennessee	Ala.	259,360	TVA
17	Ft. Patrick Henry	South Fork, Holston	Tenn.	36,000	TVA
18	Ft. Loudoun	Tennessee	Tenn.	128,240	TVA
19	Douglas	French Broad	Tenn.	112,160	TVA
20	Nottely	Nottely	Ga.	15,000	TVA
21	South Holston	South Fork, Holston	Tenn.	35,000	TVA
22	Nolichucky	Nolichucky	Tenn.	10,640	TVA
23	Wilson	Tennessee	Ala.	436,750	TVA
24	John Kerr	Roanoke	Va.	206,000	Corps of Engineers
25	Boone	South Fork, Holston	Tenn.	75,000	TVA
26	Allatoona	Etowah	Ga.	74,000	Corps of Engineers
27	Great Falls	Caney Fork	Tenn.	31,860	TVA
28	Norris	Clinch	Tenn.	100,800	TVA
29	Ocoee No. 3	Ocoee	Tenn.	27,028	TVA
30	J. Percy Priest	Stone	Tenn.	13,500	Corps of Engineers
31	Walter F. George	Chattahoochee	Ga.	130,000	Corps of Engineers
32	Cherokee	Holston	Tenn.	120,160	TVA
33	Buford	Chattahoochee	Ga.	86,000	Corps of Engineers
34	Center Hill	Caney Fork	Tenn.	135,800	Corps of Engineers
35	Blue Ridge	Toccoa	Ga.	20,000	TVA
36	Clark Hill	Savannah	S. C.	282,000	Corps of Engineers
37	Wolf Creek	Cumberland	Ky.	271,200	Corps of Engineers
38	Hiwassee	Hiwassee	N. C.	117,100	TVA
39	Fontana	Little Tennessee	N. C.	202,600	TVA
40	Apalachia	Hiwassee	Tenn.	75,000	TVA

FEDERAL HYDROELECTRIC PLANTS

INVESTMENT AND ANNUAL OPERATION AND MAINTENANCE COSTS

(DAMS AND SUBSTATIONS NOT INCLUDED)



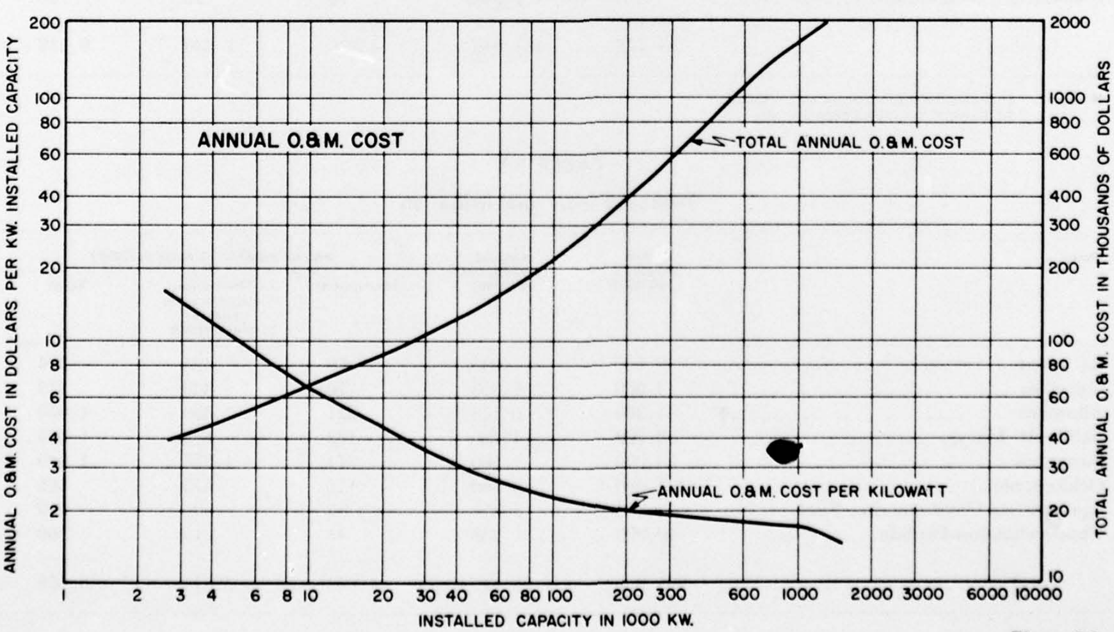


Figure 5.9

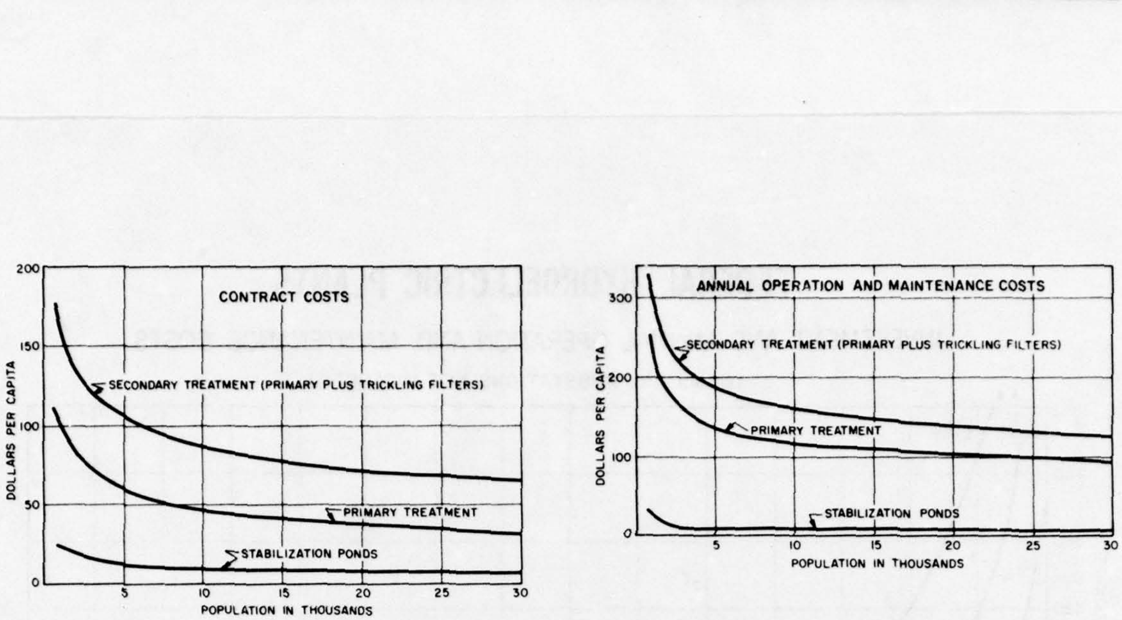


Figure 5.10 *Municipal Waste Treatment Costs.*

TABLE 5.4

Proposed Upstream Watershed Projects[1]

Basin	Drainage area (1,000 acres)	Capital investment ($1,000)[2]	Annual equivalent costs ($1,000)		
			Investment	Operation, maintenance, and re-placements	Total
Savannah	2,500	44,300	1,601	582	2,183
Ogeechee	278	3,037	110	26	136
Altamaha	1,100	15,840	573	182	755
Satilla-St. Marys	1,400	14,780	535	167	702
Suwannee	2,100	8,980	324	98	422
Ochlockonee	1,600	15,660	566	155	721
Apalachicola-Chattahoochee-Flint	1,900	30,400	1,100	400	1,500
Choctawhatchee-Perdido	900	1,949	70	29	99
Total	11,778	134,946	4,879	1,639	6,518

NOTES: [1] Includes flood prevention and drainage.
[2] Includes technical assistance costs.

TABLE 5.5

Proposed Individual Irrigation

Basin	Acres irrigated 1960-2000	Capital investment ($1,000)	Annual equivalent costs ($1,000)		
			Investment	Operation, maintenance, and re-placements	Total
Savannah	13,600	1,945	70	434	504
Ogeechee	14,000	1,953	70	443	513
Altamaha	44,200	6,113	221	1,399	1,620
Satilla-St. Marys	33,200	4,780	172	873	1,045
Suwannee	53,000	7,560	274	1,375	1,649
Ochlockonee	24,000	3,160	115	570	685
Apalachicola-Chattahoochee-Flint	17,800	2,350	85	505	590
Choctawhatchee-Perdido	10,000	1,258	45	215	260
Total	209,800	29,119	1,052	5,814	6,866

TABLE 5.6

Proposed Individual Drainage

Basin	Acres drained 1960-2000	Capital investment ($1,000)	Annual equivalent costs ($1,000)		
			Investment	Operation, maintenance, and replacements	Total
Savannah	28,000	417	15	29	44
Ogeechee	39,500	619	23	42	65
Altamaha	8,700	131	5	9	14
Satilla-St. Marys	19,700	256	9	20	29
Suwannee	32,000	534	20	18	38
Ochlockonee	3,200	50	2	3	5
Apalachicola-Chattahoochee-Flint	39,000	600	22	41	63
Choctawhatchee-Perdido	13,000	188	7	16	23
Total	183,100	2,795	103	178	281

TABLE 5.7

Proposed Soil Conservation and Utilization Measures

Basin	Acres treated 1960-2000	Capital investment ($1,000)*	Annual equivalent costs ($1,000)		
			Investment	Operation, maintenance, and replacements	Total
Savannah	889,800	22,370	809	1,781	2,590
Ogeechee	435,300	10,340	374	870	1,244
Altamaha	1,216,600	42,490	1,536	2,434	3,970
Satilla-St. Marys	178,300	8,715	315	357	672
Suwannee	947,000	21,920	792	1,894	2,686
Ochlockonee	385,000	10,360	375	563	938
Apalachicola-Chattahoochee-Flint	1,690,700	59,900	2,167	3,323	5,490
Choctawhatchee-Perdido	941,200	25,900	936	1,882	2,818
Total	6,683,900	201,995	7,304	13,104	20,408

* Includes land-use conversion costs.

TABLE 5.8

Worksheet for Single Recreation Activity Facility Costs and Benefits

Name of Area ______ Basin ______ TAUD* ______

Activity	A Participation by activities (percent)	B Annual activity days	C Design capacity factor (percent)	D Design capacity	E Activity costs for facilities per person capacity (dollars)	F Total facility costs for single activities (dollars)	G Annual operation, and maintenance costs by activity (dollars)	H Benefits: Unit values by activity (dollars)	I Benefits: Total benefits by activity (dollars)
Sightseeing			0.2		2.00			0.50	
Cultural			0.5		5.00			0.75	
Picnicking			0.8		40.00			1.00	
Swimming			1.2		20.00			1.00	
Hiking			0.5		100.00			1.00	
Camping			2.0		100.00			2.00	
Boating			0.7		20.00			2.50	
Total									

* Total annual user-days.

TABLE 5.9

Worksheet for Summary of Recreation Costs and Benefits

Name of Area________________________ Design Capacity________________________

Table 5.8, Column D

Basin________________________

CONSTRUCTION COSTS:

1. Total Facility Costs for Single Activities (Table 5.8, Column F) .... $______
2. Common Facility Costs:
   a. Parking - \$50.00 per person capacity .... $______
   b. Water Supply - \$25.00 per person capacity .... ______
   c. Sanitary - \$50.00 per person capacity .... ______
   d. Roads: (1) Class E, ______ miles @ \$44,400 per mile .... ______
      (2) Class G, ______ miles @ \$19,600 per mile .... ______
   e. Administration Area \$0.05 times Total Activity Days - Table 5.8, Column B .... ______

   Subtotal ______
3. Construction of Special Feature .... ______
4. Special Access Feature ______ miles .... ______
5. Real Estate: ______ acres @ \$______ per acre

Subtotal A .... ______

Contingencies: 15% of Subtotal A .... ______

Subtotal B .... ______

Engineering and Design, 10% of Subtotal B .... ______

Supervision, Inspection, and Administration, 8% of Subtotal B .... ______

Subtotal C .... ______

Interest During Construction[1] ______% of Subtotal C for ______ years .... ______

Total Construction Cost: .... $______

TOTAL ANNUAL COSTS:

1. Annual Amortization @ [2] ______% (0.0......) of Total Construction Costs .... $______
2. Operation and Maintenance:
   a. 3% of Subtotal C above .... $______
   b. User-day Operation and Maintenance - Total Table 5.8, Column G .... ______

   Subtotal Operation and Maintenance .... ______ ______
3. Replacement[3] ______% of Subtotal C above .... ______

Total Annual Cost: $______

Annual Net Benefits - Table 5.8, Column I $______

NOTES: [1] 2⅝% for Federal projects, 4¼% minimum for others. Percentage should be applied to half of the construction period indicated.
[2] 2⅝% (0.03614) for Federal projects, 50-year useful life. 4¼% minimum (0.04856) for others, 50-year useful life.
[3] 0.945% for Federal projects; 0.858% for others.

Costs of fish and wildlife resource development vary widely with type of project, locality, and design capacity as measured by increased production and use.

The following tables show estimated typical development costs based on experience. In estimating cost of developments proposed for the study area, appropriate adjustments were made to suit conditions at each site considered.

TABLE 5.10

Estimated Costs of Typical Wildlife Projects

Project or facility	Description	Design use or capacity (annual)	Costs: Investment	Costs: Annual operation and maintenance
Management and improvement				
Management areas (general)	10,000 acres: roadside plantings, prescribed burning, food plots, etc.	200 head big game 10,000 units of small game	0	$ 10,000
Management areas (waterfowl)	5,000 acres: Subimpoundments, food plots, roads and trails	20,000 waterfowl	0	40,000
Extensive habitat improvement	100,000 acres: border strips, food plots, prescribed burning, etc.	20,000 user-days	0	50,000
Supporting programs	Education and information, research, management services, protection and enhancement	10,000 user-days	0	5,000
New developments				
Management areas (general)	10,000 acres: lands leased for public use, roadside planting, prescribed burning, service buildings	200 head big game 10,000 units of small game	$ 50,000	20,000
Management areas (waterfowl)	10,000 acres: lands acquired in fee title with development of subimpoundments, food plantings, service buildings, etc.	40,000 waterfowl	1,000,000	80,000
Dove fields	1,000 acres: land leased, planted in crops attractive to mourning doves	5,000 user-days	0	10,000
New developments				
Large impoundments (40 acres or more)	100 acres of surface water, intensively managed	7,500 user-days	140,000	6,000
Small impoundments (less than 40 acres)	10 acres of surface water, intensively managed	750 user-days	5,000	600
Fish cultural stations (cold water)	Hatchery, raceways, administration, and service buildings	100,000 pounds trout	800,000	137,000
Fish cultural stations (warm water)	24 acres of rearing ponds, administration and service buildings, recreation facilities	3,510,000 fingerling sunfish	500,000	43,000
Fish piers (salt water)	One pier, 1,000 x 10 feet	100,000 user-days	100,000	12,000
Fishing reef (salt water)	One reef, composed of 132 concrete shelters (5x8x2½ feet) located in 25 to 80 feet of water	--	20,000	300
Water access (fresh water)	1 access development with boat launching ramps and parking area on 7 to 10 acres of land	--	12,000	400

TABLE 5.11

Estimated Costs of Typical Sport Fisheries Projects

Project or facility	Description	Design use or capacity (annual)	Costs	
			Investment	Annual operation and maintenance
Management and improvement				
Cold water streams	Production and distribution of 1,330 pounds of trout	1,000 user-days	$10,600	$2,000
Warm water streams	Rough fish control, habitat improvement, etc.	1,000 user-days	0	500
Large impoundments	Renovation of fish population, fertilization, and weed control in 10 acres of water	750 user-days	0	600
Small impoundments	Renovation of fish population, fertilization, and weed control in 10 acres of water	750 user-days	0	600
Supporting programs	Planned expenditures for education and information, management services, law enforcement, and research	1,000 user-days	0	500

TABLE 5.12

Estimated Costs of Typical Commerical Fisheries Projects

Project or facility	Description	Design capacity (annual)	Costs	
			Investment	Annual operation and maintenance
Management and improvement				
Expansion of operations	Increased fishing activity with little expansion of present fleet	--	0	75% of value of increased production
Supporting program	Exploratory fishing, biological research, market news and other services, surveys and investigations	--	0	10% of value of increased production
New developments				
Shrimp culture	10 rearing ponds of 10 acres each, with water control, administration and service buildings, utilization, and roads	80,000 pounds	$120,000	$14,000
Oyster culture	1,000 acres of suitable water bottoms conditioned and managed for sustained oyster production	870,000 pounds of meats	100,000	75,000

PART SIX – COST SUMMARIES

The following tables show estimated investment costs and estimated operation, maintenance, and replacements costs for the projects and programs in the Commission plan. Basin designations are as follows:

1. Savannah Basin
2. Ogeechee Basin
3. Altamaha Basin
4. Satilla-St. Marys Basins
5. Suwannee Basin
6. Ochlockonee Basin.
7. Apalachicola-Chattahoochee-Flint Basins
8. Choctawhatchee-Perdido Basins

Costs for the individual projects and programs by basins are shown in Appendixes 1 to 8 inclusive. Cost principles, including allocations and cost sharing, are set forth in Appendix 9, Economics.

Derivation of costs for the principal items in the comprehensive plan appear in the working papers supporting the Report.

TABLE 6.1

Investment Cost (thousands of dollars)

Purpose	Basin							
	1	2	3	4	5	6	7	8
Flood control and prevention	43,420	2,007	20,310	6,880	5,172	7,819	88,110	7,026
Water supplies	122,100	16,770	64,700	22,500	22,440	27,640	364,100	118,700
Navigation	70,480	[1]	18,130	10,890	70	13,030	272,490	16,490
Reclamation, irrigation, and drainage	3,242	3,602	7,564	13,636	13,464	13,240	8,550	2,407
Hydroelectric power and industrial development	573,400	[2]	200,600	[2]	[2]	[2]	249,450	18,080
Soil conservation and utilization	22,370	10,340	42,490	8,715	21,920	10,360	59,900	25,900
Forest conservation and utilization	92,080	34,730	90,300	46,650	86,840	64,940	127,800	100,100
Fish and wildlife	36,280	5,623	24,330	14,600	10,070	8,760	57,730	23,350
Recreation	139,800	62,800	165,600	79,980	68,280	77,920	210,800	141,850
Salinity and sediment control[3]	--	--	--	--	--	--	--	--
Pollution abatement and public health	111,140	27,250	158,800	24,190	55,410	35,240	472,500	178,200
Other beneficial purposes[4]	--	--	--	--	--	[5]55,345	--	--

NOTES: [1] Included in Savannah basin.
[2] No proposals.
[3] Included in soil conservation, forest conservation and flood control.
[4] Beach erosion control, hurricane protection, etc.; additional studies necessary but no regular program proposed.
[5] Includes only allocated cost for land transportation as part of the Gulf Coast Improvement project and land reclamation by use of spoil material as part of the Gulf Coast and Steinhatchee River Improvement projects.

TABLE 6.2

Annual Operation, Maintenance, and Replacements Costs (thousands of dollars)

Purpose	Basins 1	2	3	4	5	6	7	8
Flood control and prevention	572	17	294	79	59	78	626	48
Water supplies	6,157	987	3,478	2,592	1,138	1,810	17,468	9,682
Navigation	7,400	[1]	222	711	7	70	1,170	2,520
Reclamation, irrigation, and drainage	473	494	1,438	990	1,452	651	637	245
Hydroelectric power and industrial development	3,257	[2]	1,127	[2]	[2]	[2]	2,127	131
Soil conservation and utilization	1,781	870	2,434	357	1,894	770	3,323	1,882
Forest conservation and utilization	1,214	706	905	880	1,774	1,315	1,371	1,562
Fish and wildlife	3,593	1,106	2,166	1,602	1,598	769	6,347	2,703
Recreation	5,004	2,538	5,857	3,116	2,604	2,329	7,633	5,132
Salinity and sediment control[3]	--	--	--	--	--	--	--	--
Pollution abatement and public health	2,676	532	3,831	699	1,569	698	9,101	3,176
Other beneficial purposes[4]	--	--	--	--	--	[5]220	--	--

NOTES: [1] Included in Savannah basin.
[2] No proposals.
[3] Included in soil conservation, forest conservation, and flood control.
[4] Beach erosion control, hurricane protection, etc.; additional studies necessary but no regular program proposed.
[5] Includes only allocated cost for land transportation as part of the Gulf Coast Improvement project and land reclamation by use of spoil material as part of the Gulf Coast and Steinhatchee River Improvement projects.